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THE JOURNAL OF THE SOCIETY OF AUTOMOTIVE ENGINEERS

APRIL 1926

SOCIETY OF AUTOMOTIVE ENGINEERS Inc.
29 WEST 39TH STREET NEW YORK

Garden Variety Horse Sense

WATSON STABILATORS

They hold in proportion to the need

THE JOURNAL OF THE SOCIETY OF AUTOMOTIVE ENGINEERS

Vol. XVIII April, 1926 No. 4

Chronicle and Comment

Need for Recognized Oil Specifications

ALTHOUGH the S. A. E. Specifications for Crankcase Lubricating Oils, adopted in March, 1923, have not been recognized generally by the companies marketing oil, there is a vital need for oil specifications acceptable to both automobile builders and oil refiners. Engineers should be able to recommend definite grades of oil that are suitable for the engines they design and be assured that the public can easily obtain the grades recommended.

So that the industry may appreciate fully the prevalent conditions, H. C. Mougey, chairman of the Lubricants Division of the Standards Committee, and chief chemist of the General Motors Corporation Research Laboratories, has prepared a comprehensive statement covering the history of the S. A. E. Oil Specifications and the present situation. This statement, printed on p. 345 of this issue, warrants careful study.

Proposed Constitutional Amendment

THE voting members of the Society received last month written notice of the proposal made at the 1926 Annual Meeting of the Society that its constitution be amended to substitute for the second vice-presidency representing stationary internal-combustion engineering, a second vice-presidency representing operation and maintenance engineering.

This matter will be considered at the Summer Meeting of the Society to be held in June at French Lick Springs, Ind. The purpose of the amendment is to give the important field of operation and maintenance engineering direct specific representation on the Council of the Society. The proposed abolishing of the second vice-presidency for stationary internal-combustion engineering is based on the relative inactivity in that field so far as cooperative standardization and engineering work contemplated by the Society is concerned.

A Bigger and Better Summer Meeting

ARRANGEMENTS already completed offer unmistakable indications that the Semi-Annual Meeting at French Lick Springs, Ind., June 1 to 4, will eclipse all previous records. Details involved in the preparation of an excellent program of technical sessions and recreational activities are being handled so as to provide events of unrivalled interest and merit.

Among the engineering topics that will be discussed are Riding-Qualities, Features of Automobiles participating in the Indianapolis Speedway Race, Anti-Freeze Solutions and Compounds, Headlighting, Recent Gear-Developments, Relations between Engineering and Business, Fuels and Lubrication, and Impact-Tests on Trucks and Tires. Technical presentations will, in practically all cases, be accompanied by extensive exhibits and demonstrations.

Augmented in variety, the sports program this year will be unusually attractive. Special attention is being devoted to those activities in which the ladies have shown an interest. A very novel and sensational airplane event, the exact nature of which cannot be divulged at this time, will be featured on the afternoon of the field sports.

Additional details concerning the above-mentioned items, the Indiana Section dinner and the Indianapolis Race that will precede the Summer Meeting will be found on p. 333 of this issue of THE JOURNAL.

National Meetings Projected

ON the 2 days preceding the opening the National Air Races, probably Aug. 30 and 31, the 1926 Aeronautic Meeting of the Society will be held at Philadelphia. Extensive plans are now being formulated for this important event, which should attract a large number of the members, who will doubtless desire to take advantage of the opportunity also to enjoy the Sesqui-Centennial celebration that will be in full swing at the time of the meeting.

Chairman Rumely and the members of his Production Meeting Committee have recommended holding the 1926 Production Meeting at Chicago, Sept. 21 to 23 inclusive, during the exposition of machine-tools and equipment of the American Society for Steel Treating. Four technical sessions will be devoted respectively to Gear Production, Conveyors, Machine-Tools, and Inspection. At least two inspection visits of great interest will be arranged. The customary banquet will be supplanted this year by a stag carnival.

In November the combined Automotive Transportation and Service Meeting will take place at Boston.

Early in December the Tractor Meeting, sponsored jointly by the Society of Automotive Engineers and the

American Society of Agricultural Engineers, will be held at Chicago.

Presumably the 1926 Annual Banquet will be held at New York City on the evening of Jan. 13, 1927. The Annual Meeting professional sessions will convene at Detroit shortly thereafter.

Further information pertaining to the Society meetings for the year will be found on p. 334 of this issue of THE JOURNAL, and in forthcoming issues.

Highway-Safety Conference

PAST-PRESIDENT HORNING represented the Society at the National Conference on Street and Highway Safety held in the City of Washington last month. He, President Litle and Past-President Crane are the members of the Society's Committee on Structural Car-Elements and Safety. Mr. Crane, in a report made by him as chairman of the 1924 Conference Committee on the Motor Vehicle, stated that progress had been made by the industry on matters concerning which the Committee had made recommendations, these including headlights, brakes and features of design of car bodies and truck cabs that affect driver visibility. Mr. Horning mentioned, in addition, recent developments in steel bodies, steering-columns and low-pressure tires.

The substituting of yellow for red for the color of automobile tail-lights was favored by a large preponderating majority of those voting at the large conference, but was opposed by representatives of the automotive industry.

The result of the Conference was the turning over to the States and municipalities of a comprehensive recommended program looking to traffic control and reduction of accidents. Secretary of Commerce Hoover urged that practical action be taken throughout the Country. The problems involved can be solved only by intelligent co-operation of all concerned. Uniformity of regulatory provisions is essential.

The code agreed upon in the City of Washington includes drafts of: uniform motor-vehicle registration and certificate-of-title act, a uniform vehicle operators' and chauffeur's license act and a uniform act regulating the operation of vehicles on highways. Copies of the reports may be secured from the National Conference on Street and Highway Safety, City of Washington.

Available Reports of Specifications

TO give the members of the Society and other readers of THE JOURNAL information regarding reports of National scope that have been approved by the Society and the American Engineering Standards Committee, with which it is affiliated, a new service has been inaugurated by publishing a list of reports that are of direct interest to the automotive industries. The reports include the approved standards for commodities, manufacturing equipment and safety-codes, relating to various phases of manufacturing, that have been prepared by Sectional Committees working under the rules of procedure of the American Engineering Standards Committee, which serves as a National clearing-house for engineering and industrial standardization. The Sectional Committees issuing these reports are essentially joint National committees of representatives of various cooperating bodies, organized and working under the administrative leadership of sponsors for each project. The list also includes reports of recommended simplified practices that have been prepared under the auspices of and issued by the Division of Simplified Practice of the Department of Commerce in the City of Washington. The S.A.E. Standards and Recommended Practices and the reports of Sectional Committees are constituted of specifications that have been formulated after careful investigation and redound to the unifying of engineering practices. The simplified practice reports of the Department of Commerce are essentially lists of preferred sizes or variations of commodities, selected from those already being manufactured and used. As additional reports are approved, they will be included in the list published in THE JOURNAL. Further information regarding the general nature of the reports and the sources from which they can be obtained may be had by inquiring of the Society. The list will be found on p. 92 of the advertising section of this issue.

Headlight Activities

THE headlight problem is being taken up in the industry with a seriousness that gives promise of a real improvement in night-driving conditions, and the Society is doing its full share in pushing the movement along. The general interest that has been aroused was well shown by the attendance at the headlighting session of the Annual Meeting, which was reported in the February number of THE JOURNAL.

The Joint Steering-Committee on Headlight Research, mentioned in the January issue of THE JOURNAL, has held two meetings and has mapped out a general program consisting of four parts as follows:

(1) Collection of available data on visibility of objects under various conditions, especially laboratory results that may have some bearing on headlight problems

(2) Experimental studies of visibility of test objects under conditions representing some of the variables that affect actual driving

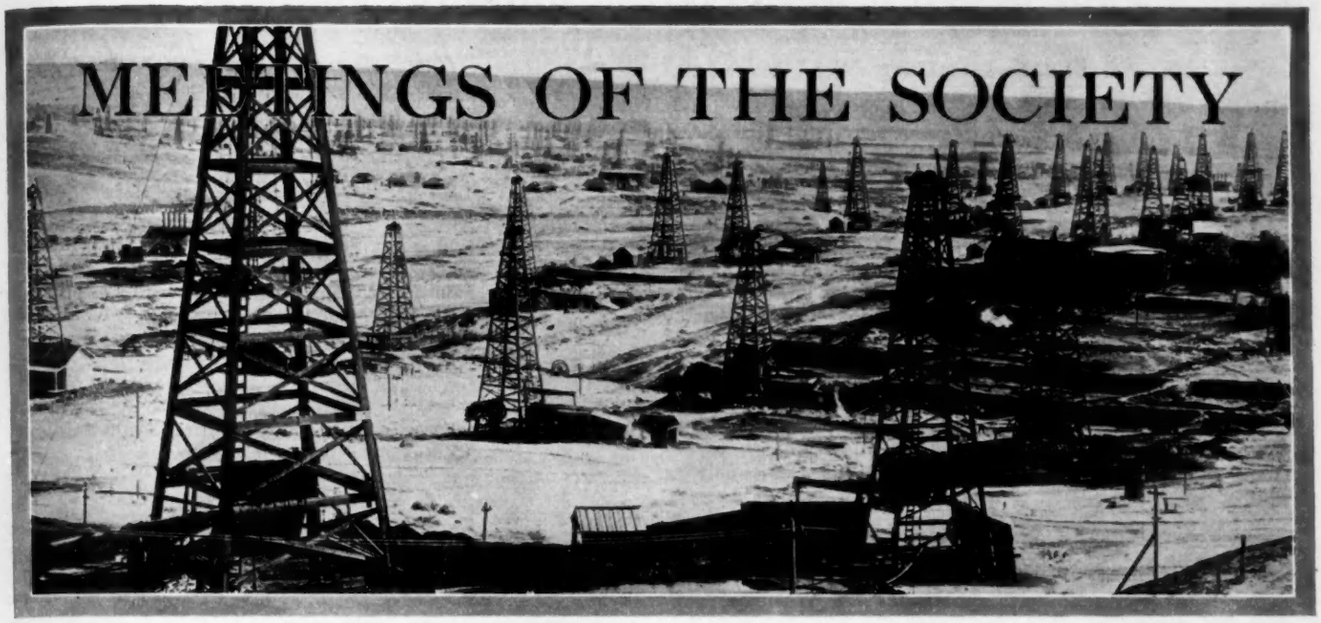
(3) Collection of data showing general condition of lamps as used on the road, the quality of equipment now being put out and the possibilities of bettering it

(4) A demonstration of cars with equipment made up by a number of manufacturers to give the types of light distribution they would consider most satisfactory for all-round use

It is expected that part (1) will be handled largely by the Nela Park laboratories of the General Electric Co., where extensive researches on the relation of vision to illumination have been under way for many years. Projects under part (2) are under consideration at the Bureau of Standards and the General Motors Corporation Research Laboratories. A. W. Devine, of the Massachusetts Department of Public Works, is obtaining data on lamps in actual use, and other subdivisions of part (3) are being dealt with by subcommittees of the Research Committee.

Part (4) of the program was given special consideration at a meeting with car builders held in Detroit on Jan. 28. A special committee is arranging to provide experimental equipment with which manufacturers and others can try out the effects of different distributions of light; and cooperative tests are tentatively scheduled to be held in June at the General Motors Proving Grounds.

All of these activities mean the investment of considerable amounts of time and money, but this is justified by the importance of improving night-driving conditions and thus promoting wider use of cars. Incidentally, it will be no small advantage if the industry itself can clear up the headlight situation so effectively as to forestall further demands for legal regulations and restrictions.



SUMMER MEETING PROJECTS TAKE FORM

Varied Technical and Recreational Program Now Nearing Completion

An engineer from a large automobile plant, who recently visited Society headquarters, reported that well over half the Society members connected with his company would attend the Summer Meeting at French Lick Springs, Ind., on June 1 to 4. He further stated that a number of his colleagues had already made reservations for accommodations at the Indianapolis Races that will be held on May 31, the day preceding the opening of the Summer Meeting, and that they were all looking forward with great pleasure to an outing that could not fail to be profitable from all angles.

Doubtless this report is typical of many that might be made, for French Lick was chosen as the meeting place because the members voted for it. No more pleasant environment could be desired, facilities for sports and recreation are among the best, housing accommodations at the French Lick Springs Hotel are adequate, the cuisine is excellent, and every other feature fully measures up to the standards that Society members demand.

The Technical Sessions

In arranging the program of technical sessions the Meetings Committee has endeavored to choose topics that are now uppermost in the minds of progressive engineers and has provided speakers who promise to bring out new thought and to reveal developments that hitherto have not been generally known.

At practically all sessions demonstrations of apparatus and exhibits of specimens will be shown; in fact at several of the sessions exhibits and demonstrations will be the main feature.

Gears

Through the courtesy of James E. Gleason, of the Gleason Works, an elaborate description of the Hypoid Gear development that promises to be of great interest in rear-axle work will be presented. H. W. Alden, of the Timken-Detroit Axle Co., promises to have the engineering story of the worm-gear drive presented.

Fuels and Lubrication

A number of automobile builders have cooperated with the Society in an extensive investigation of the causes of wear and tear in engines as they are indicated by analyses of crankcase oils obtained under operating conditions. The Bureau of Standards has conducted analyses of hundreds of samples and Otto M. Burkhardt, manager of the Society's Research Department, will come to the Summer Meeting prepared to discuss interesting findings that have developed to date. T. S. Sligh, Jr., of the Bureau of Standards, who has participated very effectively in past meetings of the Society, will demonstrate and explain new tests for automobile fuels.

One Form of Recreation That Will Be Available to Those Who Attend the Summer Meeting
Facilities for Sports Events of All Kinds Are Provided at French Lick Springs, and the Program Has Been Arranged To Afford Ample Opportunity for Taking Advantage of Them

Riding-Qualities

Do you realize the important part played by cushions and cushion-springs on your car? W. C. Keys, of the Gabriel Snubber Sales & Service Corporation, has investigated this matter thoroughly and will present the results of his research. An interesting demonstration will accompany his paper. R. W. Brown, of the Firestone Tire & Rubber Co., who in recent months has made a study of riding-qualities, perhaps more intensive than any that has been in progress, will describe novel instruments that have been used, propose satisfactory calibration methods and outline the results of many practical tests.

Headlighting Demonstration

Under the direction of the Research Sub-Committee on Headlighting, of which R. N. Falge is chairman, a demonstration of testing equipment and new developments in headlighting will be presented. It is expected that a demonstration of complementary-color headlighting will also be staged.

Duesenberg and the Races

Fred S. Duesenberg, whose cars will take an active part in the Indianapolis Races, has agreed, in an informal talk, to tell "how it is done" and to describe interesting engineering features of the racing cars that perform at the Indianapolis Motor Speedway. It is expected that Harry Miller and other prominent figures in the racing field will cooperate in making the session on the races one of the most worthwhile events of the Summer Meeting program. In all probability, several of the cars from Indianapolis and important parts will be on exhibition.

Engineering and Business

Negotiations are under way to obtain the consent of a very prominent engineering-executive with a thoroughly sound conception of engineering to deliver an address pertaining to the relationship between engineering and the commercial aspects of the automotive industry.

Other Interesting Topics

H. K. Cummings, of the Bureau of Standards, will deliver an address on Anti-Freeze Solutions and Compounds. This important subject has been carefully investigated at the Bureau and the members should be eager to learn of the facts established by this unbiased organization.

It is confidently expected that the Bureau of Public Roads will be ready to disclose the results of impact tests on trucks and tires that have been in progress at the City of Washington for many months in which the Society and the Rubber Association of America have cooperated.

There is a possibility that a paper on drop-center rim and tire developments will be given.

In forthcoming issues of the *Meetings Bulletin*, and in the May issue of THE JOURNAL, additional details concerning the program of technical sessions will be printed.

Recreational Events Scheduled

From the opening of the Summer Meeting until its close ample opportunity will be afforded for pleasant relaxation and recreation. Sports events of all kinds are being organized. Interesting and spectacular stunts are promised by several of our Sections. Special efforts will be made to provide pleasing diversion and entertainment for the ladies who attend. Their presence is greatly to be desired and they are assured of a most happy visit.

Valuable Prizes To Be Awarded

A large number of manufacturers in the automotive and allied industries, after expressing a desire to show their interest in the Summer Meeting activities in a tangible way, have subscribed very substantially to a Prize Fund to be used in connection with the sports events and recreational features of the meeting. As in past years there will be a large number of awards and the prizes will be sufficiently attractive to stimulate keen competition.

The Airplane Event

In due course, announcement will be made of an extremely interesting airplane event that is being arranged for one afternoon of the 4-day meeting.

Indianapolis the First Stop

The Indiana Section will again show its hospitality to Society members from other Sections by providing a dinner on the evening of Sunday, May 30. Judging from the Hoosiers' reputation for holding unusually attractive affairs of this nature, there will be a great demand for reservations as soon as the Section presents its formal invitation.

Many members will wish to witness the 500-mile classic that will be held at the Indianapolis Motor Speedway on May 31, the day before the Summer Meeting opens. Reservations for this event should be made *at once* by communicating with the Indianapolis Motor Speedway Co., Indianapolis.

Other Information

In due course, a series of *Meetings Bulletins*, applications for hotel accommodations, and for the reduced fare privilege on the railroads will be issued to the entire membership. Members are advised to make their plans early and to return the applications promptly in order that satisfactory accommodations may be assured.

A BIGGER AERONAUTIC MEETING

Philadelphia Chosen as Place for a 2-Day Event Preceding National Air Races in August

With the record that was established by the 1925 Aeronautic Meeting as a basis, the Meetings Committee has decided to extend the 1926 Aeronautic Meeting program over a 2-day period. In this time it will be possible to devote considerable attention to the subjects of design, construction and operation of both heavier and lighter-than-air craft.

Tentative plans indicate that the Meeting will be held at the Bellevue-Stratford Hotel, Philadelphia, on the 2 days preceding the opening of the National Air Races.

In view of the fact that the Sesquicentennial Celebration will be in full swing in Philadelphia at the time of the Aeronautic Meeting, it will be possible for the members who attend to include both attractions in their program.

A TREAT FOR PRODUCTION MEN

Plans for Meeting at Chicago in September Receive General Approval

Chairman V. P. Rumely of the Production Meeting Committee met in Detroit on Feb. 26 with a representative group of production men from the automotive industry and formulated plans for the 1926 Production Meeting that will be held at Hotel Sherman, Chicago, Sept. 21 to 23, concurrently with the Exposition of Machine-Tools and Heat-Treating Equipment of the American Society for Steel Treating.

Included in the program will be production sessions on conveyor systems and methods, automobile gears of all types, machine tools, and inspection. Two or three factory visits will be arranged and ample opportunity will be given for inspection of the exhibits at the Steel Exposition. Production men who visited last year's Exposition at Cleveland were sufficiently impressed by its practicality to recommend that the Society arrange its Production Meeting next fall so as to make possible attendance at the Exposition during the Meeting period.

Among other entertainment features a stag Carnival will be held in conjunction with the Production Meeting. According to plans already completed this will be one of the most popular events of the year.

Additional information will be issued from time to time in THE JOURNAL and in *Meetings Bulletins*.

TEST METHODS AND EQUIPMENT

Jehle Tells Milwaukee Section of Research Methods and the White Laboratory

How tests of engines and their appurtenances should be conducted and the White Motor Co.'s ideal laboratory and its equipment were described and illustrated with lantern slides by Ferdinand Jehle, research engineer of the Company, at the monthly meeting of the Milwaukee Section, which was held the evening of March 3. The technical session was preceded by a dinner and was attended by about 40 Section members, many of whom took part in the discussion. Arthur C. Wollensak, secretary of the Section, presided in the absence of Chairman J. B. Armitage and Vice-Chairman George W. Smith. Following the discussion, Mr. Wollensak read the proposed revision of portions of the Section Constitution, By-Laws and Rules. The changes are to be discussed and voted upon at the April meeting of the Milwaukee Section.

FERDINAND JEHLE

How Tests Should Be Undertaken

In his most excellent paper, Mr. Jehle dwelt first upon methods of conducting experimental work and emphasized the prime importance of planning every step carefully, including making a bibliography to learn what work others have done and avoid duplication; study of what the device is supposed to do and the designer's reasons for believing it will do it; listing all of the conditions under which it must operate and determining what information is necessary to draw conclusions as to whether or not it will meet the requirements; and planning the necessary charts for presentation of the report before starting actual test work.

Although all laboratory work should be planned so that a definite program can be followed, he said, new problems will arise within the original one and often will need to be solved before the program can be continued. Each such sub-problem also should be planned carefully. To indicate clearly the progressive steps in test procedure, he gave specific examples of an investigation of carbureters and of charge distribution to the cylinders of an engine. He first listed the requirements that a good carbureter should meet, then stated that before the effect of a carbureter on engine power and fuel economy at full load can be studied it is necessary to learn what the engine is capable of doing when it is not influenced by the characteristics of the carbureter or its setting, explained how this is done, and showed charts of the results. Tests of the carbureter at different fuel-feeds and engine speeds are then made for torque, horsepower, fuel economy, acceleration, and idling, and these were described and illustrated. The methods of comparing one carbureter with another was also described.

Studying Distribution by Pressure

The difficulties of studying charge distribution by analysis of the exhaust gases and by measurement of temperatures were mentioned and a new method involving measurement of maximum explosion-pressures in the several cylinders was described as being the easiest and most reliable. A curve of pressures when operating on natural gas is employed as a basis of comparison and the engine is then operated with the leanest possible gasoline-air mixture and the pressures in the various cylinders recorded. Next it is run on the richest possible mixture and the pressures recorded. Comparison of the last two curves shows which cylinders have too low pressure due to too little or too much gasoline. To obtain a quantitative analysis, the maximum pressures in a single-cylinder at various mixture-ratios are studied. The method of doing this was described.

Requirements of a Laboratory

After giving these examples, the speaker showed slides from photographs of the laboratory constructed and equipped by his company and described it at length. In planning a laboratory, said Mr. Jehle, a good starting point is a careful study of the work that probably will be done, but provision should be made for undertaking unexpected problems by designing the equipment so that changes can be made easily, quickly and cheaply. He listed known requirements as (*a*) the necessity of bolting equipment to the floor, (*b*) necessity of draining away water, (*c*) sufficiency of working space, (*d*) ample light throughout the space (*e*) high ceiling, (*f*) good crane transportation, and (*g*) provision for removing exhaust gases.

As for technique, the only point made was that the observer must learn to use all of his senses, particularly that of hearing as well as seeing.

Among those who took part in the discussion were Mr. Wollensak, chief engineer of the Sterling Motor Truck Co.; J. B. Fisher and A. W. Pope, Jr., of the Waukesha Motor Co.; Anton F. Brotz, of Kohler, Wis.; A. R. Constantine, of the Harley-Davidson Motor Co.; George Chandler, of the Beaver Motor Co.. Mr. Kransky, of Racine; H. D. Seelinger, of the Milwaukee Electric Light & Railway Co.; L. J. D. Healy, of the Fisk Rubber Co.; and F. M. Young, of the Racine Radiator Co.

MOTORCOACHES DISCUSSED

A. J. Scaife Presents Paper at the March Meeting of the Indiana Section

Growth in motorcoach operation, the trend in construction and the change in attitude of the steam and electric railway companies toward the motorcoach were reviewed by A. J. Scaife, chief of factory service of the White Motor Co., at the meeting of the Indiana Section at the Severin Hotel, Indianapolis, on the evening of March 11. Attending members had dinner together before the technical session, and after delivery of the paper participated in a lively discussion of the possibilities of the steam powerplant, power brakes, six-wheel suspension, and balloon tires.

A. J. SCAIFE

Chairman George T. Briggs presided over the meeting, which named F. E. Moskovics to attend the Semi-Annual Meeting as Section representative on the Nominating Committee, with F. F. Chandler as alternate.

Motorcoach Opposition Repeats History

Many lantern slides of different types and styles of motorcoach used from 1902 to the present time were shown and the speaker drew a parallel between the opposition of the rail carriers to organized highway transportation and that of the turnpike, canal, stagecoach, and steamboat companies to the railroads in the early days of the steam roads. Such opposition to motorcoaches was to be expected, he said, as

history reveals that all progressive movements have had to fight for existence.

In refutation of complaint by the railroads that motor-vehicle common carriers have an unfair advantage in that they have contributed very little to the cost of highway construction while doing more than any other agency toward wearing them out, Mr. Scaife quoted figures from a survey made by the Bureau of Public Roads showing that taxes on motor vehicles in 1924 amounted to 42 per cent of the total highway bill of the Country and to 92 per cent of the expenditures for the State and Federal highway system carrying 80 per cent of all the road traffic. Moreover, although the railroads complain of paying a large part of the cost of the highways used by their competitors, they actually paid only 3.6 per cent of the highway bill in 1924 but gained a revenue of more than $400,000,000 from the haulage of finished and partly fabricated automotive products, so that their tax bill was only 8.5 per cent of this revenue. Commercial motor-vehicles actually paid 10 per cent of their gross operating-revenue for the use of the highways, whereas the steam railroads, during a 12-yr. period ended in 1922, charged an average of only 13.3 per cent of their total operating-income to maintenance of way and structures. Although the railroads have abandoned 3800 miles of track since 1916, the operators themselves ascribe only 4.3 per cent of this to highway competition, while 58.0 per cent was due to exhaustion of natural resources and 30.0 per cent to competition by other railroads.

A decided change of attitude in the last few years, especially by electric-railway companies, is indicated by the fact that 250 such companies are now operating more than 5000 motorcoaches over 12,000 miles of route.

Trends in Motorcoach Construction

The trend in motorcoach construction was presented in figures as follows:

	1924 Per Cent	1925 Per Cent	1926 Per Cent
Four-Cylinder Engine	74	44.3	22.6
Six-Cylinder Engine	26	55.7	76.4
Unit Transmission	70	60.0	77.1
Multiple-Disc Clutch	90	86.0	81.4
Single-Plate Clutch	10	14.0	18.6
Drive-Shaft Brakes	8	5.0	8.0
Four-Wheel Brakes	14	17.0	23.0
Rear-Wheel Brakes	78	77.0	69.0
Internal-Gear Drive	10	6.0	3.7
Spiral-Bevel Drive	11	20.0	26.2
Double-Reduction Drive	20	23.0	23.4
Worm Drive	50	47.0	46.7
150 to 179-In. Wheelbase	41	36.0	35.2
180 to 199-In. Wheelbase	35	24.0	18.0
200 to 260-In. Wheelbase	24	40.0	46.7

The gasoline-electric motorcoach is attracting renewed attention, especially from the electric-railway companies, said Mr. Scaife, and, looking into the future, he declared that without question balloon tires carrying about 40-lb. pressure will be used with success on motorcoaches and will do much to revolutionize the industry by making possible the production of vehicles of lighter weight and greater carrying capacity. He believed, he said, that the future coach will weigh about 350 lb. per passenger.

About half of the discussion related to the possibilities of steam motorcoaches, for which Mr. Scaife and F. E. Moskovics foresee an important future. The advantages and possibilities of power brakes of different types were discussed by Mr. Moskovics, Mr. Scaife, C. A. Trask, and D. C. Teetor. Mr. Teetor suggested the possibility of transmitting the pressure on the oil in the engine to hydraulic brakes. Mr. Scaife said he believes that the vacuum brake possesses great possibilities because it is the simplest and, when the foot is taken from the accelerator, a high vacuum develops at once in the cylinder for operating the brakes. If anything goes wrong with the system, manual control of the brake is still available.

KETTERING ADDRESSES CLEVELANDERS

Says Prosperity Depends Upon Human-Utility Equivalent of Man-Hour

Assuming that a coolie receives 10 cents per day for performing 1 ton-mile of work, he is receiving 20 times the amount required to perform the same work on American railways. With this interesting illustration, C. F. Kettering, vice-president of the General Motors Corporation, emphasized, for the benefit of Cleveland Section members and guests at their March 15 dinner-meeting and entertainment, his contention that prosperity depends on how much a man-hour will convert into human utilities. Prosperity, he said, is gaged by the number of people that are in production.

Continuing, Mr. Kettering stated that one reason for America's prosperity is a determination, by means of research and original development, to find out what problems exist, to solve these problems, and to keep ahead of the immediate necessities of life. Thus research was demonstrated to be fundamentally a state of mind. In America there is always a tendency to apply scientific findings and to allow the public to derive benefits therefrom. Incidentally, a very large percentage of these findings are accidental, and the by-products of investigation usually more than pay for the primary research.

Delving into history "on a horsepower basis," Mr. Kettering found that the greatest advancement in the older civilization

SCHEDULE OF SECTIONS MEETINGS

APRIL

6—Buffalo Section—Thermo-Vapor-Cooling System—C. H. Kenneweg

7—Milwaukee Section—Chassis Lubrication—Fred H. Gleason

8—Dayton Section—Roots-Type Superchargers—A. W. Gardiner
Indiana Section—Worm-Drive Axles for Passenger Cars—L. Ray Buckendale

9—Southern California Section—Diesel Engines for Automotive Purposes—T. B. Danckwortt

13—Pennsylvania Section—Engine Front-End Drive—Frank M. Hawley, Robert S. Drummond and E. H. Behning

15—Metropolitan Section—Engine Characteristics as Affected by Various Cylinder and Crankshaft Arrangements with Notes on Quiet Design—H. M. Crane

19—Cleveland Section—Training of Future Executives—John Younger

23—Chicago Section—Motorized Rail-Car Development—A. W. Scarratt
Washington Section—Gasoline Production by the Vaporphase Cracking Process—William G. Leamon

came concurrently with the greatest degree of enslavement In Egypt the height of a man's pyramid was a gage of his social standing. To replenish the large supply of slaves necessary to build these pyramids the Egyptians were from time to time forced to "go out and catch a whole country."

In comparison with the Roman citizen, the average American has at his command, on a basis of a total of 7,000,000 or 8,000,000 installed hp. in this Country, 70 or 80 times as much power as had his predecessors of olden times. Thus it becomes possible for the average citizen of this Country consistently to enjoy a high degree of prosperity, for to have more than the bare necessities of life, extra work is required.

An amusing feature of Mr. Kettering's address was his statement that music is dispensed today purely on the basis of quantity production, 1 saxophone being the equivalent of 6 violins in the volume of noise produced and a 12-piece jazz orchestra equaling a 65-piece symphony orchestra. To the ear that is not too highly trained, he said, the music from one is as good as that from the other.

In the course of his address, Mr. Kettering expressed his approval of devoting funds to the promotion of pure-science research. He also stated his belief that when the present supply of petroleum is exhausted other suitable automotive fuels will be available. Several very interesting results of the application of industrial research were mentioned and the speaker also commented favorably upon the achievement of research men in the medical profession.

Entertainment Features

Under the able guidance of Edge Austin an excellent program of entertainment was provided for those who attended the dinner and listened to Mr. Kettering's address, at Hotel Cleveland. Chairman John Jaschka presided. A short business session resulted in the election of H. D. Church and Balfour Read respectively as representative and alternate on the Nominating Committee for officers of the parent Society. E. L. Jones, R. J. Nightingale and W. H. Miller were named as the committee in charge of a Summer Meeting stunt.

MOCK ON SPRING-SUSPENSION

Following a members' dinner at 6:30 p. m., the monthly meeting of the Dayton Section was held at the Engineers Club on March 10, and Frank C. Mock, research engineer of the Stromberg Motor Devices Co., delivered a paper on Spring-Suspension and Riding-Qualities. Following the presentation of the paper, there was a discussion of the subject by the members and a short business session at which the proposed amendments to the Sections Constitution and By-Laws were read and a motion made and seconded for their adoption.

BETTER-PERFORMANCE MEETING

Metropolitan Section Hears Talks on Fuels, Car Improvements and Engine Troubles

Owners of present and future automobiles should benefit indirectly but largely from meetings such as that held by the Metropolitan Section on the evening of March 18 in the rooms of the Building Trades Club, New York City, following a dinner participated in by the attending members. Three very practical and informative addresses were delivered. A. J. Kraemer, associate petroleum chemist of the Bureau of Mines and formerly connected with the Standard Oil Co. of Kentucky, gave a paper on the manufacture of gasoline; S. W. Sparrow, automotive powerplant engineer of the Bureau of Standards, pointed out ways in which cars can be improved to give better and more economical operation; and J. Willard Lord, general service-manager of the Harrolds Motor Car Co., explained the simple causes of many engine troubles and how they can be avoided. Mr. Sparrow's talk was illustrated with a number of lantern slides, and at the end of the addresses a lively discussion by a number of the members followed.

J. Willard Lord

Stanwood W. Sparrow

The meeting was opened by Secretary F. K. Glynn, in the absence of Chairman Neil MacCoull, and as a result of a ballot vote Mr. MacCoull was elected delegate to represent the Section on the Nominating Committee to meet at the Summer Meeting to nominate officers of the Society for 1927, with A. F. Masury as alternate. C. B. Veal read proposed changes in the Sections Constitution and By-Laws and moved their adoption. The motion was seconded and the matter laid on the table to be voted upon at the April meeting.

Manufacture and Properties of Gasoline

Mr. Kraemer's paper dealt with the differences in crude oils from the various fields, processes used in the manufacture of gasoline, quality of motor fuels during the last 6 years, and various properties of gasolines. Distillation and specific-gravity tables from surveys of 150 samples of gasoline, made by the Bureau of Mines in summer and winter, as thrown on the screen, showed that the gasolines of the last 2 years have been as good or even better than those of 1920 and 1921. There is no necessary relation, he said, between the gravity of gasoline and its utility as a motor fuel. On the basis of distillation tests, a light gasoline of 0.739 specific gravity and 60-deg. American Petroleum Institute gravity is much inferior to a heavier gasoline of 0.761 and 54.4 deg. Using as heavy a fuel as can be utilized by the engine has an advantage because motor fuels are sold by volume and the energy content of the heavier fuel is larger in terms of British thermal units per gallon than that of a lighter fuel.

How Car Performance Can Be Bettered

Mr. Sparrow, in his address, intimated that without increasing car prices or reducing profits the car builder can improve the operation of his vehicles. He suggested improvement along the lines of easier and quieter starting, in which the chief problem is to get the required quantity of fuel vapor into the cylinders; methods of getting oil of the right viscosity to the bearing surfaces when starting; means of avoiding excessive oil-dilution and of preventing corrosion in the engine; reduction of wear by keeping the oil clean and preventing carbon deposition; increase in fuel economy without sacrifice of hill-climbing ability by better distribution of the mixture to the cylinders and increase of the compression ratio; and greater engine efficiency by reduction in size and by higher compression and speed.

How Operators Can Improve Performance

Common causes of starting trouble, said J. Willard Lord, are too wide spark-gaps, weak battery and improper use of throttle and choke resulting in flooding of the cylinders. In cold weather the engine will start much quicker if the throttle is nearly closed. If the battery is low, starting will be facilitated by withdrawing the clutch to relieve the starter of this additional load. Excessive oil-consumption and smoking are often due to a large excess of oil in the crank-

case, to dilution and to worn bearings or burned valves. Burned bearings sometimes result from one worn cylinder or a badly fitted bearing taking all of the oil from a pressure system and starving the other cylinders and bearings. Rapid accumulation of carbon is tied-up closely, he said, with excessive oil-consumption. Engine corrosion has been the big trouble maker in winter service of late years. It can be overcome by inducing a draft in the crankcase, as by connecting the crankcase with the carbureter intake by a small pipe, and by use of an automatic radiator-shutter to keep the engine warm. He was glad, Mr. Lord said, to see a return to the marketing of glycerin anti-freeze solutions instead of alcohol, because they enable the engine to operate at higher temperatures.

Discussion of all three papers was participated in by R. W. Fulton, John McLachlan, C. M. Billings, O. M. Burkhardt, S. W. Sparrow, A. J. Kraemer, J. G. Weiss, and Ralph Van Horne. It related largely to starting difficulties as affected by temperature, corrosion, radiator shutters, oil viscosity, manifold distribution, anti-freeze solutions, ignition, and fuel; and to engine compression, cracked gasoline, and evaporative cooling.

TAXICAB AND TRUCK MAINTENANCE

Problems of Fleet Operation Analyzed at Pennsylvania Section Meeting

T. O. Day

As an example of the manner in which fleet operators should determine charges for haulage, R. O. Mason, superintendent of transportation, Philadelphia Electric Co., supplied some 200 members and guests who attended the Pennsylvania Section Meeting that was held on March 9 with the following example:

Assuming that John Doe purchased three 5-ton trucks at a total cost of $19,329.00, the interest charges at 6 per cent would amount to $1.24 per truck per working day; depreciation, assuming a trade-in value of $1,500.00 per truck at the end of 5 years, would be $3.16 per day, license fees would be $0.67 per truck per day; insurance, $1.41 per day; rental, $0.50 per day; spare driver, $1.15 per day; supervision, $1.50 per day; and garage, $0.50 per day. Thus the total fixed charges would amount to $10.13 per day.

As for running charges, the cost of gasoline and oil would be $1.34; tires, $1.00; grease, $0.01; and maintenance, $3.40; or a total of $5.75.

The operating expense per truck per day without driver would total $15.88, whereas the operating expense with a driver at $0.45 per hr. would total $20.37.

Important Operation-Factors

In outlining the points that should be investigated in taking over the operation of a large fleet of trucks, Mr. Mason stressed the importance of making a careful analysis of personnel and a suitable assignment of duties to prevent overlapping. Attention was called to the ultimate aim of assuring the availability of the maximum percentage of the fleet for use at all times. The speaker included in his discussion a brief consideration of contracts, repairs and shop layout.

The availability of accurate and well kept records was mentioned in connection with successful operation and the intelligent handling of the business features of the undertaking in general.

In the course of his address Mr. Mason stated that electric trucks are not used as much as their merit would warrant.

As regards the replacement of equipment the speaker mentioned two main factors upon which the time of replacement should depend: first, the status of used-car market values and, second, the amount that could economically be spent per mile for maintenance without jeopardizing a reasonable return on the investment.

Taxicab Operation and Control Explained

Antiquated "hire and fire" rules of employment have been rejected by the Yellow Cab Co. of Philadelphia in favor of psychological tests to determine the fitness of drivers and other employes. T. O. Day, master mechanic of the Company, explained how, by very simple tests, his company is able to test a man on a scientifically sound basis and how, by suitable compensation and the enforcement of a uniform and practical system of discipline, very high standards of effectiveness and morale are maintained.

The mechanical problem in maintaining a fleet of taxicabs is to obtain the maximum mileage at the minimum cost per mile. To bring about this situation maintenance work as carried on in four shops of the Yellow Cab Co. is classified as, first, running repairs or general service; second, day-off work; third, periodic greasing and oiling; and, fourth, periodic inspection and overhauling. Included among the departments required for these four classifications are a unit rebuild department, a paint department, a salvage department and other small units for handling sheet-metal bodies, radiators and batteries. Mr. Day described the manner in which these departments administer to the needs for servicing. The flat-rate system of compensation is in effect.

The speaker reported a distinct tendency toward the idea of exchange-units and said that stockrooms are kept well supplied with such units as engines, transmissions, clutches, front axle assemblies, steering gears, magnetos, carbureters, and differential assemblies that may be used as units to replace those that need immediate replacement. The salvage department was considered to be a very profitable adjunct. Approximately 1150 gal. of clean oil per month was said to be reclaimed at a net cost of less than 12 cents per gal.

Repainting requires a cab to be held out of service only 24 hr.

In the discussion of Mr. Day's paper it developed that sheet pyralin is used instead of window glass in the Yellow Cabs that he described. In the engine maintenance department no dynamometer tests are conducted, but repaired engines that have been run for 4 hr. are connected through transmissions with "green" engines until the latter have had 4 hr. running, and so on. It was stated that the flat-rate system of compensation requires close supervision and careful inspection.

Mr. Mason stated in the discussion that 30,000 miles or 3 years of service is expected from Ford units, 40,000 miles in 3 years is expected from cars in the Buick class and 50,000 miles in 3 years from the Cadillac class. He believed that definite conclusions as to the economical length of service of equipment should be based upon records over long periods of time. The life of heavy trucks and other equipment was said to have been extended appreciably during the past few years.

President Little Speaks

President Little honored the Pennsylvania Section by his presence and at the conclusion of the session mentioned very favorably the great value of Pennsylvania activities to both the local members and the membership of the Society at large. In connection with maintenance he stated that the life of units in the hands of fleet operators should be much greater than is the case for privately operated vehicles, this on account of possibility for more systematic and satisfactory servicing by fleet operators.

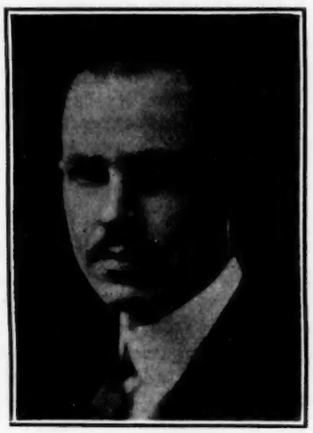
C. O. Guernsey, chairman of the Pennsylvania Section, acted as chairman of the very interesting and profitable meeting that is reported above.

TAXICAB SUPERVISION AND CONTROL DEMONSTRATED TO MEMBERS

At the conclusion of the Section Meeting, Mr. Day acted as host to some 30 members who visited the traffic department of the Yellow Taxicab Co. where the various steps in supervision and control were explained.

EFFECTS OF CAR-BUYER'S PREFERENCES

Psychology Influencing Automotive Trends Analyzed for Washington Section



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C. H. WARRINGTON

Proper cognizance of the psychology of the motor-car buyer must be taken by the automotive industry in the research, the experimental and the production departments of a given manufacturing unit, according to C. H. Warrington, president of the Warrington Motor Car Co., who presented a paper entitled the Public and the Modern Motor-Car at the meeting of the Washington Section that was held on March 5. He outlined his views regarding the probable trend of automotive engineering as influenced by public demands.

In considering the probable future lines of development and the possibilities as to whether the buying public will accept them, the speaker said that the industry is nowhere near finality in design, type or price. Obvious tendencies regarding the engine were said to be toward the employment of a supercharger that, when fully understood by the public, will be accepted and will permit the production of smaller and lighter motor cars for city use that have suitable power to be handled in congested traffic and then can be used on the highways with added speed and comfort. Oil-filters will be standardized to a greater degree and the introduction of a heating unit will be made. Further development of the air-cleaner was predicted, and was said to be desired by the public. An engine that is practically free from vibration is needed and wanted. Accessibility of parts and units is increasingly in demand.

Mr. Warrington stated also that carbureter development should be made that will permit a direct flow throughout the induction system without the intervention, and consequent complication, of jets. The ideal will be attained when engines are supplied with definitely regulated quantities of propulsive fuel and air by forced injection, so that the ratio between air and fuel will remain constant regardless of piston speed. He believes that bumpers and four-wheel-brake equipment will be made compulsory, that gear changing will become as obsolete as oil-lamps and that an infinitely variable gear-mechanism, automatically operated, will become standard design in the American motor car. Other developments cited that are in line with present trends included evaporative cooling, improved visibility through windshields, the use of non-splinterable glass, the construction of flexible bodies, the complete lubrication with a single grade of lubricant of all units from a central tank, and design that will increase durability. Non-glaring headlights are essential.

During the discussion that followed the presentation of the paper, numerous points were brought out relating to design which will improve accessibility and some consideration was given to the performance of the sleeve-valve type of engine. It was said that passenger cars and trucks can scarcely be placed upon the same basis of consideration from the buyer's standpoint at present. The factor of use is involved to such a large extent that difference in first cost in the two classes is not comparable in any sense. To the truck operator, a substantial difference in first cost is of little consequence as compared with operating cost per ton-mile. On the other hand, the overhead expense in the operation of the average passenger car is such a large component of the total running expense that economy in operating cost is dwarfed almost into insignificance. In general, the consensus of opinion appeared to be that the features added to cars as pure "sales features" embodying whatever the factory authorities think should intrigue the buyer's fickle fancy will surely be superseded by sound engineering improvements tending to provide real improvement in durability, maintenance, convenience, comfort, and operating economy.

HUNT ADDRESSES OHIO STUDENT GROUP

Future Problems in the Automotive Industry the Subject of His Address

Members of the Society's Student Group at Ohio State University gave a dinner on March 5 in honor of J. H. Hunt, of the General Motors Corporation Research Laboratories, and listened to a very interesting and instructive address by our First Vice President on Future Problems in the Automotive Industry.

Mr. Hunt was for several years connected with the electrical engineering department at the University and as Chairman of our Sections Committee has taken special interest in the activities of the Group.

RESEARCH A STATE OF MIND

Kettering Inspires New England Members by a Characteristic Address

C. F. KETTERING

Scientific research is anything that people do not understand. When understood it becomes a practical problem. Research in industry is neither entertainment nor advertising; it must make a showing on the bank balance.

Opinion and preconceived ideas are most difficult to adjust. "That's the way it's been done for a long time" represents an attitude that is hard to overcome. The human mind is against change.

Many people are afraid of facts.

Practically all things first happen accidentally and then form the basis for established conventions.

A research man is often erroneously pictured as either a "nut" or a "highbrow."

A completely free and easy mind is hard to find. We are only animal organisms. Heredity is an important item.

RESEARCH AND INDUSTRY

To many it will be unnecessary to state that C. F. Kettering, vice-president of the General Motors Corporation, was the author of the ideas above enumerated. They were included in his address at a joint luncheon meeting of the New England members of our Society and of the American Society of Mechanical Engineers on March 12 at the Engineers' Club, in Boston.

Stating that industrial research may be divided into two

phases, the personal and the material, Mr. Kettering believed that analysis and measurement constitute the most important fundamentals. By grouping individual factors it becomes relatively simple to analyze a problem step by step when the solution would be practically impossible with the problem considered as a whole. Suitable instrumentation was said to be an important factor in research.

Considering research and the customer at opposite ends of a straight line, the two are always separated, but by bending this line to form a circle, they are brought together in a relationship that should be maintained.

One of the greatest difficulties involved in carrying through industrial research arises from the fact that adjustment of one factor requires the readjustment of many contingent factors.

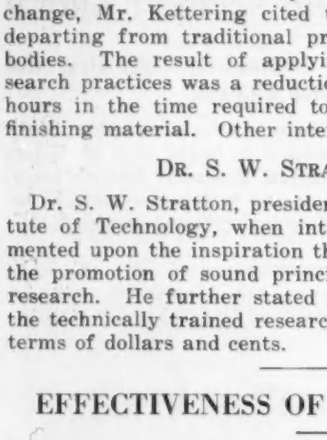
To illustrate the tendency for the human mind to resist a change, Mr. Kettering cited the difficulties experienced in departing from traditional practice in painting automobile bodies. The result of applying fundamentally correct research practices was a reduction from 37 days to only a few hours in the time required to apply and dry five coats of finishing material. Other interesting examples were cited.

Dr. S. W. Stratton Presides

Dr. S. W. Stratton, president of the Massachusetts Institute of Technology, when introducing Mr. Kettering, commented upon the inspiration that the latter had supplied for the promotion of sound principles, both in engineering and research. He further stated that the worth to industry of the technically trained research mind cannot be measured in terms of dollars and cents.

EFFECTIVENESS OF BRAKING SYSTEMS

Deceleration Comparisons and Analyses Made for Southern California Section



E. Favary

All the important types of brake in use on motor vehicles at present were analyzed at the meeting of the Southern California Section that was held on March 12, and a mathematical analysis of brake requirements was made also. John Wiggers, chief engineer of the Moreland Motor Truck Co., presented the advantages and disadvantages of brakes actuated by mechanical means, by air pressure, by hydraulic power, and by combined air and hydraulic forces. E. Favary, consulting engineer for the same company, dealt with the mathematical analysis. Eighty reservations were made for the dinner at the City Club which preceded this meeting in Los Angeles, and the enjoyment of the occasion was enhanced by the fine rendition of soprano and of tenor solos by vocalists well known locally.

Mr. Wiggers gave a comprehensive review of the developments that led to the present status of braking systems, including remedies that have been adopted to minimize or to eliminate the defects in each system, and used numerous sketches to illustrate the points he covered. Mr. Favary showed by demonstrations how the coefficient of friction of any material can be determined and how brake requirements can be analyzed by applying simple mathematical methods. In the course of the discussion that followed, the skidding qualities of solid and of pneumatic tires, and the tractive and the skidding qualities of single and dual solid-tires were compared.

Diesel Engines for Automotive Purposes will be the topic presented at the next meeting of the Section which is scheduled for April 9. It is expected that T. B. Danckwortt, an experienced designer of Diesel engines, will trace the development of this form of engine, describe the latest types in use and specify the requirements for making Diesel engines practicable for automotive usage.

LEAF SPRINGS DISCUSSED

Buffalo Section Hears Intensely Practical Report of Studies by N. E. Hendrickson

Numerous points with regard to the action of automobile springs that have been the subject of controversy for many years were lucidly explained to members and guests of the Buffalo Section at its March 16 meeting, when N. E. Hendrickson, of the Mather Spring Co., reported conclusions derived from his extensive experience and research. After describing briefly a simple apparatus, by which the oscillation of springs under different conditions of loading and lubrication were determined, Mr. Hendrickson enumerated the following conclusions:

(1) Springs and tires must flex to absorb road shocks

(2) Greater flexibility means smaller forces transmitted to the chassis but at the same time larger spring movements

(3) Spring movements mean stored energy to be dissipated

(4) This energy can be dissipated only by friction existing internally between the molecules and externally at the eyes, between the leaves or in an auxiliary energy-absorbing device

(5) Thus, the springs and tires are essentially the "shock-absorbers" of the automobile, and in performing their duties the dissipation of the stored energy becomes necessary

(6) Since the springs are not efficient in dissipating energy, it seems wasteful to make them do so by adding leaves, with consequent increase in cost and weight, and poor stress conditions. All thin leaf springs are either overstressed in their main leaves or understressed in the shorter leaves, and this is fundamental and unavoidable, as the main leaf must be thick enough to give required mechanical strength and stiffness to the eyes

(7) Interleaf friction does not retard the motion of the spring. The period or time of oscillation is fixed by the "static" deflection only and can be readily calculated from the pendulum formula. Thus, a multiple-leaf spring of given flexibility will travel at exactly the same velocity as one with the *same* flexibility but few leaves. The formula for a damped sine wave brings in an exponential and fractional factor for friction which makes its effect practically negligible as far as period is concerned

(8) Since interleaf friction is fundamentally of insufficient magnitude and variable with the propensities of individual car-owners to lubricate their springs, it seems best not to count on it for damping purposes but to use auxiliary energy-absorbing devices to apply the brakes on spring movements

(9) Oiling springs to remove temporary squeaks may not be at all detrimental to the riding-qualities of a car fitted with effective auxiliary energy absorbers. If, however, the springs *alone* have to dissipate their stored energy, the effect of oiling may be temporarily bad, but fortunately a comparatively small amount of driving will wear-out the lubricant on the small rubbing-surfaces and restore the damping qualities

The Discussion

In opening the discussion of Mr. Hendrickson's paper, J. W. White emphasized the necessity for using energy-absorbing devices, especially with balloon tires.

W. C. Keys mentioned, as four fundamentals that determine the riding-qualities of a car, the tires, the chassis springs, the energy-absorbing devices, and the cushion springs. He predicted greater use of rubber in connections between the springs and the frame.

In answer to questions propounded by A. G. Herreshoff, L. H. Pomeroy, P. B. Jackson, W. W. Slaght, D. S. Cox, and H. T. Youngren, Mr. Hendrickson stated that balloon tires have necessitated greater flexibility in the springs and that, for a given flexibility, there must be a certain weight of steel in the spring which is constantly in action during the car's motion. Springs are now being made lighter, however, than ever before, the total weight equaling only approximately 4 per cent of the weight of the empty car.

Extremely poor riding-qualities are experienced when the spring deflection approximately equals the tire deflection, thus causing an effect of synchronism that results in excessive vertical motion. This condition is avoided by the use of much softer springs with balloon tires than with high-pressure tires.

Ninety-eight per cent of the leaf springs used in automobiles are of the chrome-base type.

Any settling that takes place in springs after the spring has become properly seated, is an indication of poor material or improper treatment and design. Breakage of springs was said to be practically unknown except in the case of those used on high-speed motorcoaches.

No difficulties were said to be experienced in springs utilized with the Hotchkiss drive.

Chairman Pomeroy brought out an interesting point when he mentioned the definite relation that exists between periodicity of walking and that found in present-day passenger-cars.

ST. LOUIS MEMBERS CONVENE

Hydraulic Brakes and Other Topics Discussed at Informal Meeting

For some weeks a goodly number of enthusiastic members of the Society in St. Louis and vicinity have gathered informally from time to time for the discussion of automotive matters of common interest. Their most recent meeting was held on March 19 when a paper on Hydraulic Brakes was read by Burns Dick, chief of the brake division of the Wagner Electric Co. Mr. Dick's address was followed by addresses from G. H. Kublin, chief engineer of the Moon Motor Car Co., and A. J. Mummert, works manager and chief engineer of the McQuay-Norris Mfg. Co. The general discussion that followed the three addresses covered practically the entire field of manufacturing, operation and service. Nearly every member present participated actively in this discussion.

Among those who have been instrumental in carrying on Society activities in St. Louis are W. L. Dempsey, G. P. Dorris, F. W. Gardner, V. C. Kloepper, G. H. Kublin, and A. H. Timmerman.

DETROIT SECTION RECEIVES A WARNING

Sparrow Says That Compression-Ratios'll Get You If You Don't Watch Out

Cheese, in the form of greater engine-power production with lessened fuel-consumption, is the bait that lurks inside the mousetrap of high compression-ratios to lure the engineer to his destruction, but woe be to the engineer who thinks he can grab a big hunk of the cheese known as increased power and efficiency from such a trap without paying the price demanded. Even as a mouse fears a trap but likes the cheese

NATIONAL MEETINGS CALENDAR

SUMMER MEETING
French Lick Springs, Ind.—June 1-4

AERONAUTIC MEETING
Philadelphia

PRODUCTION MEETING AND EXPOSITION
Hotel Sherman, Chicago—Sept. 21-23

TRANSPORTATION AND SERVICE MEETING
Boston

TRACTOR MEETING
Chicago

ANNUAL DINNER
New York City—January, 1927

ANNUAL MEETING
Detroit—January, 1927

and nibbles at it, the engineer fears high compression-ratios but delights in increased power and efficiency and continues to nibble at them. And the end is not yet.

It was in the foregoing analogous style that S. W. Sparrow, of the Bureau of Standards, presented his subject, Engine Design and Anti-Knock Fuels, at the meeting of the Detroit Section that was held on March 11, and the speaker may be said to have discussed the high-compression-ratio trap and its bait and why the engineer continues to nibble, his purpose being to save engineers from being caught.

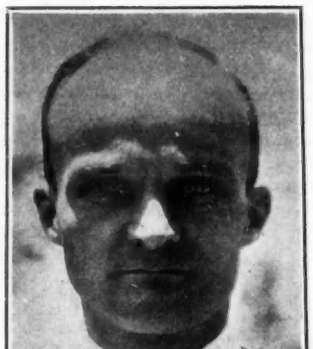
Exhibiting an indicator-card taken from an aviation engine, showing pressure well above atmospheric existent at the end of the stroke, Mr. Sparrow mentioned that every now and then someone discovers this condition and is horrified that the gas, willing and eager to push the piston another 4 or 5 in., is allowed to go whistling merrily through the exhaust-valve. Apparently, this energy should be utilized by increasing the expansion ratio and would result in a gain of power and efficiency without increasing the compression-ratio and necessitating a search for special anti-knock fuels. Seemingly, it is a chance to get the cheese without going near the trap, but the mechanical difficulties of constructing an engine having an expansion ratio much greater than its compression-ratio intervene. Such engines can be built, but this is not done because a rather large increase in stroke gives only a small increase in power. The reason is tied-up with the air-cycle efficiency, and it was analyzed by Mr. Sparrow. It also seems that what is essentially the same scheme, in the disguise of reducing the clearance volume to give what appear to be extremely high compression and expansion ratios, would secure the desired result; but this would seriously reduce the effective piston-displacement of the engine. Since the foregoing schemes are impracticable, Mr. Sparrow assumed the compression and expansion ratios to be equal, in his subsequent discussion, and that any change that was made in one necessitates a corresponding change in the other.

After analyzing other pitfalls that are met in connection with preignition, detonation, supercharging, and adjustable compression-ratios, some of the advantages of using a high compression-ratio were stated. Among these it was said that what an increase in compression-ratio makes possible is a smaller engine for the power desired rather than the production of surplus power. The efficiency with which the charge is burned in the engine cylinder increases as the compression-ratio is increased, in the same ratio as that of the air-cycle efficiency. For example, the efficiencies of the 7.5, the 6.5 and the 5.5 ratios would be, respectively, 22, 17 and 9 per cent greater than that of the 4.5 ratio. However, the car-owner's gasoline bill depends upon the mechanical efficiency as well as upon the thermal efficiency, and this is intimately related to the subject of engine size per horsepower. Calculations included in the analysis of the foregoing statement showed that, for example, the over-all gain to be derived from changing from a 4.5 to a 6.5 ratio would be 27 per cent. According to Mr. Sparrow, we can be confident that, as anti-knock fuels become available generally, compression-ratios will be increased and fuel economy will be increased thereby. As to the statement frequently made that "high-compression engines run rough," he believed this is not due to the fact that the compression is high but rather to the fact that it is too high for the fuel employed. In the tests made at the Bureau of Standards, no evidence of "roughness" existed even when the engine was operating at the 14 to 1 compression ratio, with a compression pressure of 400 lb. per sq. in.

The questions asked during the general discussion of the paper brought out further explanations by Mr. Sparrow of the important points he had covered.

JAMES ADDRESSES SAN FRANCISCANS

Fuel Volatility and Continuous-Distillation Tests Subjects of March Meeting



W. S. James

Asserting that the batch-distillation methods for testing fuel volatility are unsatisfactory, W. S. James, of the Associated Oil Co., explained at the March 17 meeting of the Northern California Section that continuous-distillation methods should receive very serious consideration as a means of defining gasoline volatility in figures that are significant when translated into terms of production and use.

If this laboratory method of continuous distillation is truly representative of the process of vaporization that occurs in an engine, said Mr. James, translating the test temperatures into those of use should be possible if (*a*) the reduction of hydrocarbon vapor-pressure due to the presence of air and (*b*) the effect of pressure on the temperatures of vaporization could be estimated. Since the results of tests show an approximately linear relation between temperature and per cent of bottoms, a fair assumption is that the temperature of 50 per cent bottoms is the average boiling-point. The average molecular weight can then be estimated from the boiling-points of pure hydrocarbons.

Mr. James called attention to the relationship between fuel volatility and crankcase-oil dilution. He demonstrated apparatus to show the proposed methods of test.

FUEL AND METAL-CONTROL PROGRESS

Remedy for Dilution and X-Ray Metal-Testing Described to Chicago Section

Elaborating his previous paper, Suggested Remedy for Crankcase-Oil Dilution, which was published in the February, 1926, issue of THE JOURNAL, R. E. Wilson, member of the research council for the Standard Oil Co. of Indiana, presented additional data on the subject at the meeting of the Chicago Section that was held on March 26 and Dr. George L. Clark, of the Massachusetts Institute of Technology, delivered a paper on the Industrial Application of the X-Ray,

THE SUMMER MEETING

A GREAT ATTRACTION!

French Lick Springs, Ind. June 1, 2, 3, and 4

Immediately Following the Indianapolis Races

in which the possibilities for use of the X-ray in determining the existence of strains in metals and for analyzing the effects of annealing processes as to whether they are correct for certain materials were set forth. Dr. Clark stated that proper material for any specific use can be determined positively without extensive tests, by an X-ray analysis of molecular structure and that defects of materials due to manufacturing processes and defects in heat-treatment also can be detected precisely in this manner.

A dinner preceded the technical session, and both were well attended. Snappy discussion followed the delivery of the papers, and great interest in the X-ray and its industrial possibilities was evidenced.

At the conclusion of the meeting, a vote of thanks was extended to the speakers.

The proposed amendments to the Section Constitution, By-Laws and Rules were passed by both the Governing Committee and the Section's members.

GEAR DESIGN AND CUTTING

At the March production meeting of the Detroit Section, on March 25 in the General Motors Building, the topic of the evening was Recent Developments in Gear Design and Gear-Cutting, by John Bethune, of the Reo Motor Car Co. The technical session was preceded by a members' dinner. No definite arrangements have been made as yet for the April meetings of the Section.

LEAF SPRINGS

HADFIELDS of England manufacture automobile leaf springs that embody certain special characteristics in design, material and manufacture. The spring leaves are made from strip of flat section, which is not the form generally used. It has been customary in the past to manufacture leaf springs from stock of slightly concave section. In this way a spring of good appearance can readily be produced without special care, since the edges of the leaves when assembled make contact with an apparent freedom from gape. Hadfields contend that a spring with leaves of hollow section is not so good as one built up from perfectly flat leaves. Apart from other considerations, a spring in which the pressure between the leaves is transmitted solely through the edges must embody unequal stresses.

Perhaps still more important is the fact that such a spring does not fulfil one of the main functions of the spring, namely, that of damping. Further, with the rapid wear that subsequently takes place along the edges under the concentration of pressure, such damping as exists initially becomes very greatly modified. Efficient and sustained damping action, with equalization of stress and even wear, can only be assured with plates of flat section. A further feature of Hadfield's springs is to be found in the contour of the ends of the leaves. This is of special form, with the object of securing the best transmission of stresses from one leaf to another. It is sometimes contended that this is a point of little consequence; it is, however, not unimportant since with leaf ends of unsuitable shape very considerable concentration of stresses is set up at their points of bearing on the adjoining leaves, making these points, therefore, relatively weak. It is claimed that, with the Hadfield form of leaf-end, uniform stress throughout the spring is more nearly achieved than with any other.

In the manufacture of the springs the rolled eye is favored in preference to the solid forged eye, and when a full technical analysis of the various points is made, this form of eye has much in its favor. For instance, the continuity of the grain structure is preserved in that portion of the material forming the eye. Since the leaf is subjected to heat-treatment as a whole, it follows that there is no heterogeneity of structure such as is produced in the operation of forging a solid eye. Confirmation of this is found in the fact that failure in a solid-eyed leaf usually occurs at the junction of the eye and the leaf.

It is sometimes claimed that in the case of cars fitted with front-wheel brakes it is advisable to use a solid eye as having greater longitudinal strength with which to withstand the heavier stresses on the springs. The following account of an experiment carried out to test this point is furnished by Hadfields. The end of a master leaf of ¼ x 2-in. section prepared with a rolled eye was fitted with a standard shackle and pin. The whole was submitted to a tensile pull through suitable grips in a Whitworth testing-machine, with a view to ascertaining the load at which perceptible opening of the eye occurred. It was found that a total pull of 6¼ tons was registered before the eye opened 0.001 in. measured circumferentially. The section of steel and size of eye tested were those in use for a car weighing about 2800 lb. Any method of calculating the end stresses on the springs due to the rapid braking of such a car, even when based on the highest possible rate of retardation, does not lead to anything like the figure obtained in the test. From this it is evident that there is an ample margin of safety in the rolled eye. The strength of 6¼ tons is, in fact, many times greater than the stresses likely to occur even under the most severe conditions.

After the registering nibs have been made, each leaf is separately hardened. Suitable tempering completes the leaf. By the old rule-of-thumb methods the spring-maker's skill was necessary in fitting the leaves together. By the Hadfield methods they require no particular attention in assembly, each one being of the correct camber and without any warping. "Setting" operations are thus practically eliminated, greatly to the advantage of the spring, since these must be performed on the hardened steel leaf in the cold, to the detriment of its physical condition. Every spring manufactured is given a deflection test on assembly, and there is no doubt that an excellent-looking component is produced. Examination of the separate leaves by straight-edge across the strip shows that when these come to assembly the faces are perfectly flat and true. A uniform surface contact is therefore provided between the leaves throughout the finished spring.—*Automobile Engineer.*

EXPORTATION OF AUTOMOBILES

A TRULY remarkable achievement of American industry in 1925 is the increase of nearly 60 per cent over 1924 in the number of automobiles exported, raising the automobile to a rank in our export trade surpassed only by cotton and mineral oils. Every indication is that this remarkable advance will continue; largely because of the general improvement of world economic conditions, the lowered prices of our automobiles, the inability of most European producers to satisfy demand, and the exploitation of hitherto undeveloped markets, stimulated in several important instances by the Department of Commerce. Outstanding examples of increased purchases of American automobiles in 1925 over 1924 are: Belgium, 36 per cent; Denmark, 700 per cent; Norway, 30 per cent; Brazil, 154 per cent; and United Kingdom, 260 per cent.—Julius Klein, director of the Bureau of Foreign and Domestic Commerce.

DIESEL ENGINES

IT is fairly well known that on the Continent the application of the Diesel engine to road vehicles has reached the stage of commercial production. It seems that we are a little behind the times, although it is understood that at least one British firm has an aircraft engine operating on the Diesel principle. This engine is, we believe, running continuously in other work with a view to ascertaining its useful life and other pertinent factors. It is, in fact, in aircraft work that perhaps the Diesel offers the greatest advantage. A satisfactory engine operating on this principle would remove almost entirely that most serious of all drawbacks to air travel, the fire risk. In this connection the Diesel might well revolutionize air transport.

Working, as it does, on the injection system, such an engine will function on a much wider range of fuel than engines of the mixture or explosion type, and in addition give a lower fuel-consumption. It is estimated that if oil refining were reorganized to meet a general demand on these lines the supply of suitable distillates would go three times as far as for the gasoline engine.

The Diesel engine has certainly made remarkable strides in other spheres. It is, of course, employed in factories and pumping and generating stations, and as a marine unit is challenging the position of steam. In the last 3 years the percentage of Diesel-engine to steam-engine ship-tonnage under construction has risen from 12 to 98 per cent. In several countries experiments have been conducted with Diesel railroad engines, mostly for local traffic. In Russia they have recently put into service main-line Diesel locomotives.

It is curious that a principle offering such advantages has not been earlier developed for road transport. This is doubtless to some extent attributable to the fact that the automobile engineer, having started on the development of the present type of prime-mover, continued with it, there being no very special inducement to change to another type. However that may be, as far back as 1908 a high-speed oil-engine for automobile work was constructed, and numerous designs, mostly of an experimental nature, have been produced since, culminating in the Continental design already mentioned.

Numerous problems are of course presented, but none of these seems incapable of solution. Heavy oil needs a greater quantity of air for combustion, which involves larger cylinders. The pressure must be high to ensure efficiency, probably from 400 to 500 lb. per sq. in. Speeds must be relatively low, in the region of from 800 to 900 r.p.m. If blast injection were employed, a compressor to deliver air at 800 lb. per sq. in. would be required to spray the fuel into the cylinder. A solid-injection system would dispense with the compressor but involve the use of a variable-stroke fuel-pump, governor-controlled, capable of delivering fuel to the cylinder at from 800 to 1000 lb. per sq. in.

Undoubtedly, one of the big problems of the small Diesel has been the matter of fuel injection. It is necessary to deliver with precision a few thousandths of a cubic inch of fuel in a few thousandths of a second, and this through a spray orifice 0.001 or 0.002 in. in diameter. To raise the engine speed much above 800 or 900 r.p.m. reduces, of course, the already small time-element, and further complicates the problem. Starting from cold needs some auxiliary means, such as a reduction of compression, lighter fuel, compressed air, electric motor, or combinations of these.—*Automobile Engineer.*

IF YOU GET THE CHANCE, GRAB IT

RICH opportunities, not only for engineer members, but for non-technical minds alive to the value of the "liberal" education available at slight cost, at very interesting gatherings of interesting men—

That is what meetings of the Society of Automotive Engineers are. As to the cost, it is away below the cost of production, meaning by that the long years of study it takes to produce the light the technical minds shed, usually so simply that others can grasp the ideas in the subjects quickly.

The engineers do the digging. Their non-technical listeners, lucky fellows, get the benefit thereof.

Anyone who has a chance to attend these meetings should do so. Take *Motor West's* word for it, you will be gratified. You will find, among other things, that the engineers do not pretend to know it all. Carburetion, for instance, a representative of this journal learned by listening in recently, is as frankly a mystery to a notable number of these trained students as it is to laymen who have studied it at random. This is not at all to the discredit of the technicians. It is due to the elusiveness, the fineness, of the factors that have to be dealt with; and as the relation of these to each other and to the desired composite result—efficient and economical fuel service—finally will be mastered, think of what that means, in view of the very excellent results obtained so far! To hear discussions of such subjects, and quite possibly to be among those asking questions of speakers, as is the custom, is not only to gain but to give knowledge, as the questions may impart suggestions that will increase engineering data and so hasten results.

The engineering angle is the truth-seeking angle. A good engineer rarely is a good faker. His natural bent is to find out what is the very best way to do a thing. His field no longer is restricted to mechanical or chemical things. He is becoming more and more the leading factor in ordinary business. It is being predicted that soon our industrial leaders will be engineers, not mere money-getting bargainers. This prediction is in accord with the common-sense, economic rather than sloppy sentimental, development of cooperation in many forms, in industry. In some respects our lives are becoming highly specialized and mechanicalized, but on the whole we are moving more and more as an intelligent mass that has the punch of personal initiative, plus collateral force. We are living much better, more sensible, comfortable, productive lives than our predecessors did, despite the temporary turmoils we are all growling about; and though we only faintly realize it, we are working toward much better conditions—we are in the transitional period—and the engineering minds, the truth-seeking minds, the let's-find-the-best-way minds, are the ones that are doing the most to help us all in that direction.

Lacking invitation to be a member, or to attend meetings of the Society of Automotive Engineers in your locality, be a seeker. You will be welcome as a visitor, according to *Motor West's* observation; and you will receive much for very little, every hour you spend among these unostentatious scientific men, who have been shown by psychological tests to have the straightest-thinking, least-kinked-up minds among us. That sort of thing is contagious. Get some of it.—*Motor West.*

STANDARDIZATION ACTIVITIES

The work of the Divisions and Subdivisions of the S. A. E. Standards Committee and other standards activities are reviewed herein

S. A. E. OIL SPECIFICATIONS REVIEWED

H. C. Mougey, Lubricants Division Chairman, Outlines History and Present Status

H. C. Mougey

The S. A. E. Specifications for Crankcase Lubricating Oils, adopted in March, 1923, have not been recognized generally by the companies marketing oil, but there is, however, a real need for oil specifications acceptable to both automobile builders and oil refiners. Engineers should be able to recommend definite grades of oil that are suitable for the engines they design and be sure that the public can easily obtain the grades recommended.

In order that the industry may appreciate conditions, H. C. Mougey, chairman of the Lubricants Division of the Standards Committee and chief chemist of the General Motors Corporation Research Laboratories, has prepared the following statement covering the history of the S. A. E. Specifications and the present situation. Copies of this statement have been referred to all builders of automotive vehicles so that future reports of the Lubricants Division can be considered by the automotive industry with a full appreciation of the standardization work to date and the problems involved.

Early Tests to Detect Adulteration

Before the discovery of the oil fields in Pennsylvania lubricating oils were composed of animal and vegetable oils, such as lard-oil and castor-oil, but very shortly after the opening of these fields petroleum lubricating oils appeared on the market. At first, these petroleum oils were looked upon with suspicion and were considered as being very much inferior to animal and vegetable lubricating oils. In many cases mixtures were made of these petroleum lubricating oils and animal or vegetable oils, and frequently these mixtures, costing much less than the pure animal or vegetable oils, were sold at the regular prices without any mention being made of the fact that they contained large quantities of petroleum lubricating oils. This practice of using the petroleum oils for adulteration was looked upon as being very wicked and chemists and oil experts set about to find means of detecting such adulterations. Certain tests were developed which gave different values for petroleum oils and for animal and vegetable oils, and these tests were used principally to detect adulteration or substitution with little regard to whether they had any relation to the values of the oils for lubricating purposes. Among these tests were viscosity, specific gravity, flash, fire, pour, acid and saponification numbers, and the like. The viscosity test was valuable not only in detecting substitution or adulteration but in choosing the proper oil for the desired use. However, in most cases, the normal values given by the Pennsylvania oils for specific gravity, flash, fire, pour, acid and saponification numbers, and other tests were being looked upon as being very bad and as evidence of adulteration.

The use of Pennsylvania oils continued, however, and since they were low in price and gave good lubrication, they gradually replaced the animal and vegetable oils on the market, regardless of their values for specific gravity, flash, and fire, and other tests. Shortly after the merit of the Pennsylvania oils had been established, oil fields in the Central, Western and Southwestern parts of the United States began to be developed, and these newer oils came on the market in competition with the Pennsylvania oils. The chemists and oil experts found that these Western and Southwestern oils differed somewhat from the Pennsylvania oils in the values they gave to the tests for specific gravity and flash, fire and pouring temperatures, and Pennsylvania oil values, which originally had been developed to detect adulteration and to indicate inferiority, came to be regarded as values that a high-grade lubricant should have, regardless of the fact that in many cases no relation could be shown between these values and the lubricating value of the oil.

The history of these Western and Southwestern oils was similar to that of the Pennsylvania oils. At first they were looked upon with suspicion, but gradually they developed a place for themselves based on genuine merit, and today good lubricating oils are made from oils from Pennsylvania, Ohio, Oklahoma, Texas, Mexico, and California, although they do differ somewhat in specific gravity, and in their flash points and other characteristics. Under certain conditions the best results in an engine may be obtained with a Texas or California oil and under other conditions with a Pennsylvania oil, but the fact remains that automobiles are used all over the world with good results with a large variety of oils.

The property of an oil most important in determining its suitability is the viscosity, but even in the case of viscosity the limits may be much wider than are generally supposed, especially when it is remembered that the temperature of the oil in the crankcase may vary from below 0 to over 212 deg. fahr. and the dilution may vary from practically nothing to a very high value, the average in the United States being probably around 15 per cent in summer and 25 per cent in winter. The changes in viscosity that these changes in temperature and dilution produce are very great, as is shown in Table 1.

TABLE 1—VISCOSITY IN SAYBOLT UNIVERSAL SECONDS AT DIFFERENT TEMPERATURES AND WITH DIFFERENT PERCENTAGES OF DILUTION FOR ONE OF THE MOST WIDELY USED AND ADVERTISED OILS IN THE UNITED STATES

Dilution,	Temperature, Deg. Fahr.				
Per Cent	0	70	100	130	212
0	270,000	2,100	585	220	57
15	20,000	560	200	100	44
25	8,000	280	117	70	—

When used in an automobile engine, a certain percentage of dilution is practically always found in all oils, even though the engine be fitted with a device to decrease this dilution. As a result the oil in the crankcase with which the engine is actually lubricated would almost never pass any recognized oil specification based on the accepted values for specific gravity, flash and fire points, color, and other characteristics.

S.A.E. Specifications Adopted in March, 1923

In 1921 the Government Lubrication Specifications were drawn up to facilitate the purchase of oil by the Government. Shortly afterward the Lubricants Division of the Standards Committee submitted practically the same specifications to the S.A.E. Standards Committee and they were adopted by

TABLE 2—PROPERTIES OF OILS NOW USED IN MAKING BLENDS

Oil	Specific Gravity at 60 Deg. Fahr.	Viscosity at 100 Deg. Fahr.	Viscosity at 210 Deg. Fahr.	Flash	Fire	Color	Conradson Carbon	Pour Test, Deg. Fahr.
Western Cylinder Oil	0.9240	1,918	106	475	515	3	0.29	..
Eastern Cylinder Oil (Bright Stock)	0.8945	....	143	540	610	6½ (1 to 1)	1.19	..
Western Neutral Oil	0.9305	205	41	320	390	2	0.05	— 5
Eastern Neutral Oil	0.8720	210	47	410	475	4	0.12	+30

the Society in March, 1923. They are now printed on p. D151 of the S.A.E. HANDBOOK. The S.A.E. Lubricating Oil Specifications are not in general use and for many reasons the possibility of their ever coming into general use appears to be slight. In the specifications the oils are classified according to the viscosity at 100 deg. fahr. for the low-viscosity oils and at 210 deg. fahr. for the high-viscosity oils, with the values for flash, fire, color, Conradson, carbon, and other tests chosen so that all normal oils, regardless of the geographical source, will meet the requirements. Although millions of gallons of oil are sold and successfully used each year with values within the limits given by the S.A.E. Lubricating Oil Specifications, it is true that practically no oil has all the minimum and all the maximum values specified. For example, the Western refiners regularly make oils that have values much lower than those specified as permissible maximums for the pour, color and carbon residue tests. Eastern refiners make oils that have values much higher than the permissible minimums for the flash and fire tests. Refiners of both kinds of oil do not want to mark their oils as being in accord with the S.A.E. Lubricating Oil Specifications, as they feel that by so doing they will be classifying them with oils which they feel are inferior to their own oils, at least in certain respects.

In Tables 2 and 3 are given the values for four oils of a viscosity of 500 sec. at 100 deg. fahr., together with the values for the oils that were blended to make the four 500-sec. viscosity oils. For purposes of comparison the specification for an oil of 500-sec. viscosity at 100 deg. fahr. is also given.

In an attempt to overcome this difficulty the Lubricants Division suggested several specifications for each viscosity range, one for Eastern oils, one for Western oils, and one for a mixture of Eastern with Western oils. The oil companies objected to having several specifications for oils of the same viscosity, as this seemed to indicate that the oil which met the specification with the highest maximums or the lowest minimums would be considered by the public as being superior. In addition, it was felt that an infinite number of specifications for oils of each viscosity range would be required to meet commercial conditions.

REAL NEED EXISTS FOR DEFINITE NOMENCLATURE

The real need for S.A.E. Lubricating Oil Specifications is to provide a system of nomenclature that will enable the automobile engineers to recommend oils suitable for use in the engines they design and build, and to enable the oil companies to make the oils they sell so that the public can buy oils of the grades recommended by the automobile builders.

H. C. Dickinson, of the Bureau of Standards, had previously tried very hard to have the larger oil companies agree on the viscosities represented by the terms "Light," "Medium," "Heavy" and the like, but without success, since these names were tied up with the trade-marked names and the advertising of the oil companies, and since the same viscosity might be called "Light" by one company, "Medium" by a second and "Heavy" by a third. One company might sell an oil of a certain viscosity as a "Heavy" automobile oil and the same or another oil of the same viscosity as a "Light" tractor oil.

Another factor that caused trouble in attempts to standardize the viscosity limits of any one grade of oil was the old dispute between the advocates of the Eastern and the Western oils in regard to the temperatures at which the oils should be compared. Due to the differences in their respective viscosity-temperature curves, if an Eastern and a Western oil are chosen so that their viscosities at 210 deg. fahr. are the same, the Western oil will be heavier than the Eastern oil at temperatures below 210 deg. fahr. For this very reason the refiners of Eastern oil were at a disadvantage when the temperatures below 210 deg. fahr. were chosen at which to compare viscosities, and they insisted very strongly that all oils should be compared at 210 deg. fahr. On the other hand, the refiners of the Western oils preferred 100 deg. fahr., since their oils had a higher viscosity at 100 deg. fahr. than the Eastern oils, even if both oils had the same viscosity at 210 deg. fahr. and it was clearly impossible to properly compare an oil at both 100 and 210 deg. fahr. at the same time.

STANDARD TEMPERATURE OF 130 DEG. FAHR. PROPOSED

In an attempt to break this deadlock on specifications, viscosities of different grades, temperatures at which viscosities should be compared, and similar points, Dr. Dickinson suggested that the viscosities should be compared at only one temperature for a given viscosity oil, and that the viscosity grade be known by a number instead of, or in addition to, the name "Light," "Medium" or "Heavy," which in so many cases was hopelessly tied up with trade names and advertising. The committees of this Society and the American Society for Testing Materials, representing the automobile industry and the oil industry, realized the value of Dr. Dickinson's suggestion, and a subcommittee of Committee D-2 of

TABLE 3—PROPERTIES OF OIL BLENDED FROM THE OILS GIVEN IN TABLE 2

Oil	Specific Gravity at 60 Deg. Fahr.	Viscosity at 100 Deg. Fahr.	Viscosity at 210 Deg. Fahr.	Flash	Fire	Color	Conradson Carbon	Pour Test, Deg. Fahr.
Western Cylinder Oil plus Western Neutral Oil	0.930	500	57	360	410	3	0.15	10
Eastern Cylinder Oil (Bright Stock) plus Western Neutral Oil	0.919	500	60	375	420	6	0.45	+15
Western Cylinder Oil plus Eastern Neutral Oil	0.892	500	62	450	500	6½	0.20	+25
Eastern Cylinder Oil (Bright Stock) plus Eastern Neutral Oil	0.883	500	66	455	505	6½	0.56	+35
S.A.E. No. 50	...	450–475	50 min.	355 min.	400 min.	5 (7 kerosene +3 oil)	60 max.	+50 max.

the American Society for Testing Materials was appointed to see what could be done. This subcommittee suggested the temperature of 130 deg. fahr. for purposes of comparing viscosities of the low-viscosity oils ordinarily used in automobiles and 210 deg. fahr. for the high-viscosity oils ordinarily used in tractors, trucks, etc. Some of their reasons for choosing 130 deg. fahr. for testing the lower-viscosity oils are that it is

(1) One of the three temperatures recognized as standard by the American Society for Testing Materials. These temperatures are 100, 130 and 210 deg. fahr.

(2) Nearer an average crankcase-oil temperature in automobiles than either 100 or 210 deg. fahr.

(3) A good compromise between the temperatures of 210 deg. fahr. desired by the Eastern oil men and of 100 deg. fahr. desired by the Western oil men, since if an Eastern oil and a Western oil have the same viscosity at 130 deg. fahr. the Eastern oil will have a lower viscosity below 130 deg. fahr. and a higher viscosity above 130 deg. fahr, with the reverse for the Western oil

(4) The temperature that has been used by the Navy for a number of years

(5) A temperature that permits a much more accurate viscosity determination for the low-viscosity oils than 210 deg. fahr. since the Saybolt instrument is not reliable when used in determining viscosities as low as those of the low-viscosity automobile oils at 210 deg. fahr.

TABLE 4—SUGGESTED S.A.E. OIL-VISCOSITY NUMBERS

Probable S.A.E. No.	Viscosity Range at 130 Deg. Fahr.	Viscosity Range at 210 Deg. Fahr.
10	90–115	..
15	120–145	..
20	185–220	..
30	255–300	..
85	..	75–95
110	..	105–120

For the higher-viscosity oils ordinarily used in trucks or tractors 210 deg. fahr. was chosen as the standard temperature. Some of the reasons for this choice are that 210 deg. fahr. is

TABLE 5—COMPARISON OF VISCOSITIES AT 100 AND 210 DEG. FAHR. OF OILS OF THE SAME VISCOSITY AT 130 DEG. FAHR.

Viscosity at 100 Deg. Fahr.		Viscosity at 130 Deg. Fahr.	Viscosity at 210 Deg. Fahr.	
Lowest Viscosity, Eastern Oil	Highest Viscosity, Western Oil	Eastern or Western Oil	Highest Viscosity, Eastern Oil	Lowest Viscosity, Western Oil
158	170	90	46	43
220	215	115	49	46
230	265	120	50	47
290	340	145	54	49
390	460	185	61	53
470	560	220	66	56
550	700	255	72	60
660	875	300	80	62

Note:—Mixtures of Eastern and Western Oils will have viscosities between the above ranges.

(1) One of the American Society for Testing Materials standard temperatures

(2) Nearer the average crankcase-oil temperature in trucks and tractors than 100 deg. fahr.

(3) Now recognized as the standard temperature for high-viscosity oils

(4) A temperature that permits accurate viscosity determinations on the higher-viscosity oils

To avoid the confusion due to the names "Light," "Medium," "Heavy," and similar designations, it has been suggested that the oil and the automobile companies agree on numbers to represent the viscosities. By taking numbers representing one-tenth of the viscosity at 130 deg. fahr. and the actual viscosity at 210 deg. fahr., a series of numbers, in an increasing order, would be obtained which could be used to represent the viscosity. This would enable the public to obtain an oil of the desired viscosity and would not interfere with any trade-names or the names "Light," "Medium," "Heavy," and the like that are now used by the oil companies and that could continue to be used by the oil companies even though this proposed system should come into general use.

TABLE 6—COMPARISON OF VISCOSITIES AT 100 AND 130 DEG. FAHR. OF OILS OF THE SAME VISCOSITY AT 210 DEG. FAHR.

Viscosity at 100 Deg. Fahr.		Viscosity at 130 Deg. Fahr.		Viscosity at 210 Deg. Fahr.
Lowest Viscosity, Eastern Oil	Highest Viscosity, Western Oil	Lowest Viscosity, Eastern Oil	Highest Viscosity, Western Oil	Eastern or Western Oil
575	1,625	265	480	75
1,050	4,500	440	1,000	95

Note:—Mixtures of Eastern and Western Oils will have viscosities between the above ranges.

To illustrate how the oils could be classified a list of viscosity numbers suggested by the Subcommittee of the American Society for Testing Materials, together with the viscosities at 130 and 210 deg. fahr. according to which temperature is chosen for making the viscosity comparison, is given in Table 4. In Tables 5 and 6 the lowest and highest values for Eastern and Western oils at 100, 130 and 210 deg. fahr., with the same suggested viscosity at 130 or 210 deg. fahr., are given.

The type of specification in which the properties of flash and fire temperatures, viscosity, color, pour test, and the like are given is in reality a "purchasing agent's specification" and is of very little value to the individual owner of a motor car. It is of great value to a purchasing agent in securing competitive bids on oils and to check the identity or uniformity of shipments. The system of viscosity grading discussed above is not intended to replace the present system of "purchasing agent's specifications" now in use by both the refiners and the vehicle builders but to enable the automobile owner to obtain oil of the proper grade or viscosity. The matter of the proper degree of refining the oil is left to the refiners, and permits the oil companies to retain any prestige they have built-up through their sales advertising policies.

The committees representing the American Society for Testing Materials and this Society are now working on this problem. Their work will be useless if the oil companies do not mark their oils so that the public can get oils of the desired grades, and if the automobile engineers do not recommend oils of the proper grades. This discussion does not represent any official action at the present time but is offered so that the engineers can decide more intelligently on any system of oil specifications or of oil-viscosity grading that may be submitted by the committees now at work on the problem.

SECTIONAL COMMITTEE ACTIVITIES

Wire and Sheet-Metal Gaging Sectional Committee To Be Organized

Following the proposal by the Society last November that a Sectional Committee be organized under the procedure of the American Engineering Standards Committee for the standardization of the methods of gaging wires and metal sheets, strips and plates, a general conference of industrial interests was held under the auspices of the American Engineering Standards Committee in New York City on March 18. Discussion at the conference indicated that wire and metal sheets are at present being specified to some 30 odd gages but that the tendency throughout the several industries to use a straight decimal fraction system of designating wire

diameters and sheet thicknesses is growing. It was evident from opinions expressed at the conference that the project will be a very important one and far-reaching in its effects but that without doubt standardization of gages will be of great value. A résumé of the American and foreign gaging systems was given which indicated that definite American Standards can be developed but that probably international standardization would be much more difficult. It was finally recommended by the conference that a Sectional Committee should be organized under the sponsorship of the American Society of Mechanical Engineers and this Society. It was also recommended that the scope of the project should be the standardization of a method of designating the diameter of metal and metal-alloy wire, the thickness of metal and metal-alloy sheets, strips and plates and the wall thickness of tubing, piping and casing made of these materials; and the establishment of a standard series or a number of standard series of nominal sizes of wires, sheets, strips, and plates and tolerances for them.

Meeting on Pins and Washers

On March 19 meetings of the Subcommittees on Pins and Washers of the Sectional Committee on Pins and Washers were held in New York City to organize the Subcommittees, determine the scope of their work and to lay down their programs. The Subcommittee on Washers which met in the morning decided that its report should include lock-washers, various types of punched or cut washers and cast washers including the malleable type. The varieties of washers, however, will be restricted to the conventional designs and will not include specialized proprietary types.

The Subcommittee on Pins met in the afternoon and prepared a program covering taper and straight machine-pins, dowel pins and various conventional types of split pins including the usual cotter type and various other forms that are used in railroad, locomotive and car design.

The gathering of data on the various types of washers and pins was assigned to particular members of the Subcommittees with the expectation that tentative reports may be drafted some time in May or June. The Sectional Committe on Pins and Washers was sponsored by the American Society of Mechanical Engineers and this Society.

STATUS OF STANDARDS ACTIVITIES

Seven Division Meetings To Be Held in the Early Part of This Month

The Division Reports to be acted upon at the Standards Committee Meeting at the Society Summer Meeting at French Lick Springs, Ind., will be printed in full in the May issue of THE JOURNAL in order that members interested in the reports will have an opportunity to study them prior to the meeting. Although final action is being taken on many reports by letter-ballot, several Divisions are holding meetings during the early part of April.

April Division Meetings

Division	*Date*	*City*
Lubricants	April 2	Baltimore
Electrical Equipment	April 5	Cleveland
Lighting	April 6	Cleveland
Engine	April 7	Chicago
Transmission	April 8	Detroit
Parts and Fittings	April 9	Detroit
Screw-Threads	April 12	New York City

As the work before the various Divisions of the Standards Committee is of special interest to the Society members at this time, the more important subjects now under consideration are covered in the following summary of the status of the Standards Committee work. Information with reference to any of the subjects under consideration, or copies of any reports that have been submitted, will be sent to Society members interested.

Aeronautic Division.—The Division work has been limited largely to cooperation with the Joint Army-Navy Aeronautic Standardization Conferences. It is expected that the Army-Navy Standards issued to date will be acted upon by the Aeronautic Division by letter-ballot and submitted for publication in the S. A. E. HANDBOOK at the Summer Meeting.

Axle and Wheels Division.—Division reports recommending the cancellation of the present S. A. E. Standards for wood spokes for passenger cars and motor trucks, printed on pages F1 and F1a of the S. A. E. HANDBOOK, and increasing the solid-tire felloe-band widths to agree with the nominal widths will be submitted at the Summer Meeting.

Ball and Roller Bearings Division.—It is expected that the Subdivision Report on Roller Bearings, presented as a progress report at the January Standards Committee Meeting, will be submitted for action at the Summer Meeting. This report has been submitted to all roller-bearing users for criticism. The Division is also considering the standardization of metric-type thrust ball-bearings. The possibilities of international standardization are being considered.

Electrical Equipment Division.—At the April 5 Division meeting it is expected that Subdivision reports covering revisions in the existing S. A. E. Specifications for electrical instrument and oil-gage mountings, flexible steel conduit, generator and starting-motor mountings, ground-return wiring systems, timer-distributor mountings, and insulated cable will be submitted for final Division approval. A report recommending a definite color code for autombile wiring is also to be submitted.

Engine Division.—At the Engine Division meeting on April 7 Subdivision reports will be submitted on three-bolt type carbureter flanges, carbureter intakes, engine support arms, engine testing forms, piston-rings, piston and piston-ring oversizes, and starting-cranks. It is expected that these reports will be approved in original or amended form and submitted for Standards Committee action in June.

Iron and Steel Division.—Three members of the Iron and Steel Division are represented on the joint committee of members of the American Society for Testing Materials, the American Society for Steel Treating and this Society on heat-treatment definitions. It has been impossible for the joint committee to agree on a final report to date owing to certain points of difference. Subdivisions are developing specifications for the Rockwell hardness test and for sheet steel tests. Special cooperative tests are also to be made by the Subdivision on Physical-Property Charts to determine the possibility of establishing a basis for the charts that will indicate the physical properties most likely to obtain.

Lighting Division.—It is expected that the Lighting Division will take final action at the April 6 meeting on a majority of the subjects assigned to it. In some cases Subdivisions will hold meetings on April 5 to complete their reports. The subjects assigned are two-filament lamp connectors, electric incandescent lamps, body-lighting switches, head-lamp construction, lighting nomenclature, head-lamp reflectors, head-lamp mountings, signal lamps, and tail-lamp illumination.

Lubricants Division.—The work of the Lubricants Division is reviewed in this issue of THE JOURNAL on p. 345. A definite report is expected as a result of the Joint Meeting of the Subcommittee of the American Society for Testing Materials and the Lubricants Division in Baltimore on April 2.

Motor-Truck Division.—Although the S.A.E. Recommended Practice for Three-Joint Propeller-Shafts was withdrawn at the January Standards Committee Meeting, a Subdivision is developing a specification representing current engineering practice. The Division will also review the present standard for hub odometers, as it is believed that this specification can be simplified considerably.

Parts and Fittings Division.—Final Division action will probably be taken at the April 9 meeting covering lock-washers, brake-lining dimensions, flexible metal tubing, gasoline-tank filler-tubes and caps, gasoline-tank gage caps, keys and keyways, rivets, vacuum-tank mountings, and rod-ends.

Passenger-Car Body Division.—Under the chairmanship

(*Concluded on p.* 403)

AUTOMOTIVE RESEARCH

The Society's activities as well as research matters of general interest are presented in this section

COOPERATIVE FUEL-RESEARCH

Review of Progress Made and Suggestions for Future Work on This Project

With the growth of the automotive industry the demand for motor fuel has shown a continuous increase. This fact was recognized years ago not only by this Society but also by the American Petroleum Institute and the National Automobile Chamber of Commerce. With characteristic foresight the two last-named organizations have for several years been giving financial support to the carrying out of cooperative researches pertaining to the fuel problem in general. With financial support assured, the Society through its Research Committee laid out a research program. This provided for a comprehensive study of the influence of gasoline volatility upon the satisfactory and economic performance of cars and trucks in this Country. A number of car builders were approached and, realizing the value of such research, they agreed to carry out tests with various grades of fuel, taking particular note of power, acceleration and economy. The program specified that a large number of stock cars should be operated using four selected grades of fuel. The results of the tests were submitted to the office of the Society for correlation.

The first series of these tests was carried out in the summer of 1922. It was, of course, recognized that atmospheric temperatures would have to be taken into consideration. Therefore, immediately after the completion of the summer tests, arrangements were made to carry out similar tests during the winter.

While this work was in progress, it was observed that one of the main difficulties encountered with the fuels of low volatility was excessive crankcase-oil dilution. New problems arose continually, such as the influence of the volatility of the fuel and the temperature of the cooling medium and the lubricating oil on the dilution of the oil. Consequently, the original program was expanded to include a thorough investigation of important factors that influence dilution.

Considerable laboratory work was carried on simultaneously at the Bureau of Standards in the City of Washington. The Bureau's results on crankcase-oil dilution have been very gratifying.

Much credit is due the Bureau of Standards for very valuable suggestions and for participating in the program by conducting laboratory and road tests.

At a meeting of the Research Committee at White Sulphur Springs last June Past-President Horning, in reviewing the progress that had been made, expressed great appreciation of the work and of the many valuable papers that had been presented at the Society's meeting in connection with it. He proposed that the Bureau of Standards be asked to state the most important findings of these cooperative tests in condensed form. Accordingly, a resume of the results was prepared by the Bureau of Standards. This is presented herewith in the hope that it will serve as a convenient permanent reference.

Summary of Cooperative Fuel-Research Results

This summary, which is based upon the results obtained up to April, 1925, is divided into two parts, (*a*) a comparison of the four fuels used and (*b*) crankcase-oil dilution. The first of these is given in Table 1.

Conclusions are based upon results obtained with motor-vehicle equipment produced in 1920 and representing 75 per cent of the equipment in use at the time of the test. It was found that

(1) In general the same power and fuel economy are obtained with all four fuels, under warm conditions

(2) Under cold conditions, particularly at low loads, the fuel consumption increases as the volatility decreases. The quantity of fuel required for maximum acceleration increases as the volatility of fuel decreases

(3) Crankcase-oil dilution increases as the volatility of the fuel decreases. It is likely that the use of *D* fuel instead of *B* will increase the dilution as much as 50 per cent

If less volatile fuels are to be used, the improvements in design that are likely to be of most service are those which will reduce crankcase-oil dilution and improve performance at low temperatures particularly as regards acceleration and operation at low loads. When changing from one fuel to another, changes in jet sizes or other adjustments may be necessary because of differences in the viscosities of the fuels. Refiners should strive for uniformity in fuels in order that frequent adjustments of the carbureter may not be necessary.

TABLE 1—PHYSICAL CHARACTERISTICS OF THE FOUR TEST-FUELS

	Fuel							
	A		*B*		*C*		*D*	
	Deg. Cent.	Deg Fahr.	Deg. Cent.	Deg. Fahr.	Deg. Cent.	Deg. Fahr.	Deg. Cent.	Deg. Fahr.
Distillation, Initial	49.0	120	52.0	126	51.5	125	54.5	130
10 Per Cent	83.0	181	83.5	182	84.5	185	89.0	192
20 Per Cent	94.0	201	96.3	205	102.0	216	104.5	221
30 Per Cent	105.0	221	106.7	225	113.5	237	116.0	241
40 Per Cent	113.5	237	116.3	241	124.5	257	128.0	262
50 Per Cent	121.0	250	126.2	259	134.0	275	139.0	282
60 Per Cent	130.0	266	136.0	277	145.0	293	153.0	307
70 Per Cent	139.5	284	148.0	298	159.0	318	170.5	338
80 Per Cent	149.5	302	163.7	327	176.5	351	194.0	381
85 Per Cent	158.0	316	172.0	342	186.0	367	204.0	399
90 Per Cent	171.5	342	185.0	365	201.0	394	218.5	426
95 Per Cent	192.0	378	203.0	397	218.0	424	233.0	452
End, or High Point	206.5	403	214.0	417	229.5	446	244.5	472

Conclusions Regarding Crankcase-Oil Dilution

Length of Period of Operation.—The relation between time of operation and amount of dilution differs for different engines and for different conditions of operation. Dilution tends to reach an equilibrium condition but the extent to which the oil is diluted when this condition is reached may be such as to render it unsuitable for use.

Fuel Volatility.—The dew-point of the fuel determines whether or not fuel condensation and therefore dilution will take place under given temperature conditions.

Jacket-Water Temperature.—The temperature of the jacket water determines to a large extent the temperature of the cylinder-wall and thus is one of the most important of the factors that affect the rate of crankcase-oil dilution. The rate of dilution increases as the jacket-water temperature decreases. It is important that the time required for the engine to reach normal operating-temperatures be short.

Air Temperature.—The influence of air temperature upon dilution is not great for the reason that it affects primarily the condition of the fuel when it enters the cylinder and not

its condition after it strikes the cylinder-walls. Dilution depends primarily on the condition of the fuel after it strikes the cylinder-walls. The air temperature does however affect the amount of vaporization of fuel that takes place prior to ignition and hence the air-fuel ratio that is required for proper running. It therefore indirectly affects the rate of crankcase-oil dilution through its influence upon the air-fuel ratio.

Load.—Under test conditions, the rate of dilution was found to vary almost directly as the load. If, as is the case with most engines, an increase in load results in an increase in jacket-water and entering-air temperatures and the like, the influence of these factors may partially offset the increase in dilution that would otherwise result from the increase in load.

Air-Fuel Ratio.—The rate of dilution increases with an increase in the air-fuel ratio and often in almost direct proportion to such increase.

Viscosity of Oil.—No evidence has been found of a consistent relation between viscosity or any other characteristic of an oil and the rate of dilution. While this phase of the investigation has not been at all exhaustive, there appears to be no reason to anticipate any such influence.

Temperature of Oil in Crankcase.—The temperature of the oil exerts a major influence upon the amount of dilution, the amount decreasing with an increase in temperature. Probably the influence of the oil temperature is due to its effect upon the rate at which the diluent is eliminated from the oil. It is not probable that the temperature of the oil has any great effect upon the rate at which the diluent enters the oil, as the temperature of the oil upon the cylinder-wall is governed largely by the temperature of the jacket water.

Number of Piston-Rings.—Tests in which only one piston-ring was employed did not show any material increase in rate of dilution over tests in which the full set of three rings was employed. A material increase in dilution was found when no rings were used. From this it appears that, while reasonably well-fitting piston-rings are desirable, it is not probable that the dilution rate could be materially reduced by extreme refinements in piston-ring construction.

Fit of Piston.—Tests in which the diametral clearance between piston and cylinder had been increased 1/32 in. showed no material increase in dilution rate. It does not appear probable that any material reduction in dilution rate can be obtained by excessively close piston-fits.

General Discussion of Dilution

If the temperature of the oil-film upon the cylinder-walls is below the dew-point temperature of the air-fuel mixture, liquid striking this film will not be evaporated and vapor striking the film will be condensed. The influence of the various factors that have been mentioned can usually be traced to an influence upon the temperature of the film upon the cylinder-wall, the dew-point of the air-fuel mixture or the extent to which the oil-film upon the cylinder-wall is exposed to the mixture; for example, with no piston-rings or with extremely poorly-fitting rings the charge would have access to a portion of the cylinder-wall from which it would be excluded by well-fitting rings. The excessively high rate of dilution that occurs when starting in cold weather is due to the fact that the walls are very cold and the air-fuel ratio very high, a fuel content more than 10 times as great as that necessary for normal operation frequently being required.

If the rate at which the diluent is evaporated from an oil is fairly rapid, the rate at which the diluent enters the oil can also be high without any serious accumulation resulting. The rate of elimination of the diluent is affected by the temperature of the oil, its rate of circulation and the amount of ventilation in the crankcase.

To reduce crankcase-oil dilution when using a given fuel it is desirable to:

(1) Operate with high cylinder-wall temperatures
(2) Reduce the time required to bring the engine up to normal operating-temperatures
(3) Reduce the time of operation with rich mixtures
(4) Operate at high oil-temperatures
(5) Provide adequate ventilation in the crankcase

Measurement of Crankcase-Oil Dilution

Two methods are available for the measurement of crankcase-oil dilution: a very accurate method known as the vacuum distillation transition method and a simpler method known as the capillary funnel method. The latter gives results that are correct within 1 or 2 per cent, which is ample for most purposes. Descriptions of both methods can be obtained from the Bureau of Standards.

Starting difficulties were recognized years ago as being due to lack of volatile constituents in the fuel. Therefore, an investigation of factors that contribute to easy starting has been carried on as a part of the cooperative fuel-research. Interesting results were obtained and presented by J. O. Eisinger, of the Bureau of Standards, at the 1925 Summer Meeting[1] and the 1926 Annual Meeting[2] of the Society.

These starting tests have been discussed at length at various meetings of the Research Committee and of the Cooperative Fuel-Research Steering-Committee. At these meetings it has been emphasized that a study should be made of physical and chemical characteristics other than the distillation curves of fuels. For instance, it is expected that vapor-pressure-temperature curves will give some very reliable information on starting characteristics. At one of these meetings Past-President Horning favored not only making a study of the physical chemistry of motor fuels but also establishing an index for definitely measuring intensity of detonation. At present different investigators use various methods for testing detonation. The results so obtained do not lend themselves to ready or convenient comparison.

In the desired study of physical characteristics of fuels some progress has already been made. At the 1926 Annual Meeting, W. S. James presented some interesting views pertaining to the subject.[3] He observed that fuels in the manifold and in the cylinder are vaporized by what is commonly termed continuous distillation. However, the conventional laboratory method for testing fuel volatility consists of batch distillation. In an endeavor to determine whether fuel volatility can be measured by continuous distillation, Mr. James conceived and built an interesting apparatus for demonstration. At the same Society meeting, T. S. Sligh, Jr., showed two different kinds of apparatus that had been constructed at the Bureau of Standards for studying fuel volatility and the conditions under which fuel-air mixtures ignite.[4]

Problems Suggested for Future Research

This represents in brief the salient points of the Cooperative Fuel-Research carried on so far. It is of course desired to continue this work. For this reason, the Research Committee at its meeting on Jan. 29 discussed the desirability of conducting another fuel-volatility test similar to that of 1922 and 1923. However, upon due consideration it became evident that carbureters and manifolds of low-priced cars have not changed sufficiently since the last test was made to justify a repetition of it. Moreover, it is thought that an economic balance has been reached between gasoline and kerosene; oil producers must continue to make kerosene. Therefore, no advantage would accrue from finding out whether cars can use gasoline of lower volatility.

In view of this, the Research Committee is at present confronted with the problem of crystallizing opinions as to the future research that should be carried on. The Cooperative Fuel-Research should, of course, be of such nature that the results will be of equal interest to both the automotive and petroleum industries.

As previously stated, some members have expressed the

(*Concluded on p.* 401)

[1] See THE JOURNAL, July, 1925, p. 52.

[2] See THE JOURNAL, February, 1926, p. 147.

[3] This paper will, it is expected, be published in an early issue of THE JOURNAL.

[4] A paper describing this apparatus will be found on p. 393 of this issue of THE JOURNAL.

Vol. XVIII April, 1926 No. 4

Automobile Head-Lamp Light-Characteristics and Improved Distribution

By Walter D'Arcy Ryan[1]

Annual Meeting Paper *Illustrated with* Photographs and Charts

ABSTRACT

SUBSEQUENT to reviewing the circumstances responsible for the present complicated situation existing with respect to satisfactory automobile-headlighting, the author says that headlights glare if they are adjusted for range and that, when adjusted for non-glare, they have no range; hence, careful tests were made on a number of the best types of approved headlight and lens in use. The units were set-up in pairs, in operating position as to height and interval and were tested at a range of 100 ft. with a 1-m. (39.37-in.) hemisphere having an aperture 21 in. square, corresponding to 1 deg. at 100 ft. All the lamps were held at proper current-value throughout the tests, and it was demonstrated by the tests that the reflectors of the parabolic type and others of similar characteristics that have proved to be unsatisfactory during many years past must be abandoned.

Regarding the so-called "hot-spot" of light on the road to facilitate high-speed driving and the tendency toward such practice lately evidenced, the author sees no reason that anything beyond 20,000 cp., maximum, is required, and says that half this candlepower would be sufficient in a well-balanced light. The main light-beam should have a good lateral spread so that it will cover for a considerable distance not only the road but also the ditches, with reasonable depth so as to carry a gradually diminishing illumination to within say 20 ft. of the car, and should illuminate the wheels and the running-board of the approaching car clearly at a distance of at least 200 ft. without projecting any direct rays into the eyes of the approaching driver.

Commenting upon fog penetration, the practice of "dimming," tilting reflectors, and two-filament lamps, the author says that headlights of the future should have range without glare and should not require tilting, dimming or any other form of manual operation. He believes that the two-filament lamp will do much to improve the present situation, states specifications for improved headlights and discusses the tests and the illustrations.

DESIGNERS of the early electric automobile-headlights had the one thought in mind of producing the maximum amount of light ahead to satisfy the man behind the steering-wheel; they had no thought of the effect of such headlights on the approaching driver, a feature apparently considered only recently. Their effort to outshine everything on the road resulted in an intolerable and dangerous situation which increased with the automobile traffic until, with millions of automobiles on the roads, it has become necessary to enact laws to protect the automobile drivers from each other. Exhaustive tests, which resulted in the so-called "I.E.S. Specifications" that many States have adopted, were made by the Illuminating Engineering Society. They were not advocated as being ideal specifications but were formulated on the basis of a compromise between glare and range of sufficient light on the roadway for safe driving, based on the best available units in existence at the time of the tests in question and also based on the automobile-traffic situation then existing. These specifications, which have stood for so many years with only one addition, appear to be the best basis so far offered as a first line of elimination, provided that we are to continue the use of headlights having the same general light-distribution characteristics as we are using today; the Society's specifications are mainly based on them but show higher values at certain points.

Accident statistics were studied and conclusions were drawn to the effect that although glare is disagreeable and dangerous it is not the primary cause of night accidents, a greater number being attributed to insufficient light on the roadway. Further analysis probably would have shown that improper distribution of light on the roadway, irrespective of the number of lumens delivered, was responsible for a large percentage of the accidents. Glare is the only thing that ever put me in a ditch or caused me to turn a car over by side-swiping it on account of misjudging the passing space available. I believe that the public feels glare to be a greater menace than anything else we have to contend with at night. As a result, the automobile adjusters, irrespective of any specifications issued, are depressing the head-

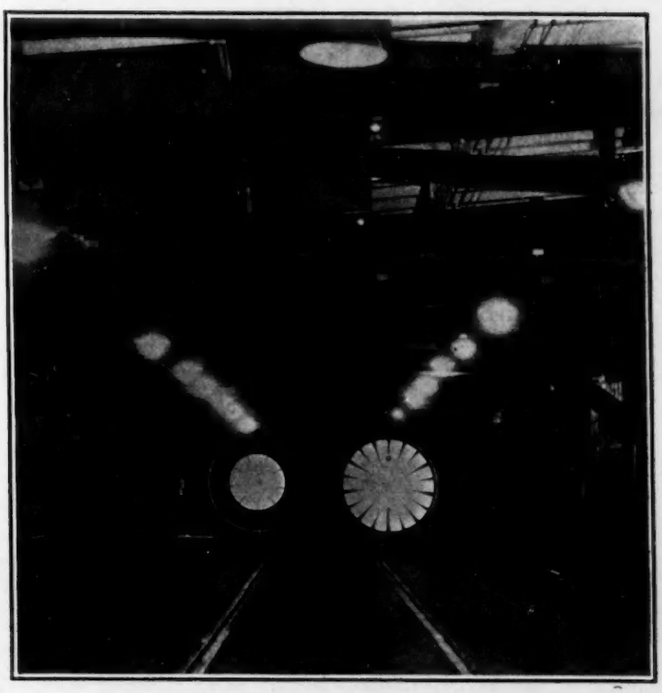


Fig. 1—Searchlight-Testing Range
Extensive Automobile-Headlight Investigations Have Been Conducted in the Last 3 Years in This 155-Ft. Searchlight-Testing Range Located in the Illuminating Engineering Laboratory of the General Electric Co.

[1] Director, illuminating engineering laboratories, General Electric Co., Schenectady, N. Y

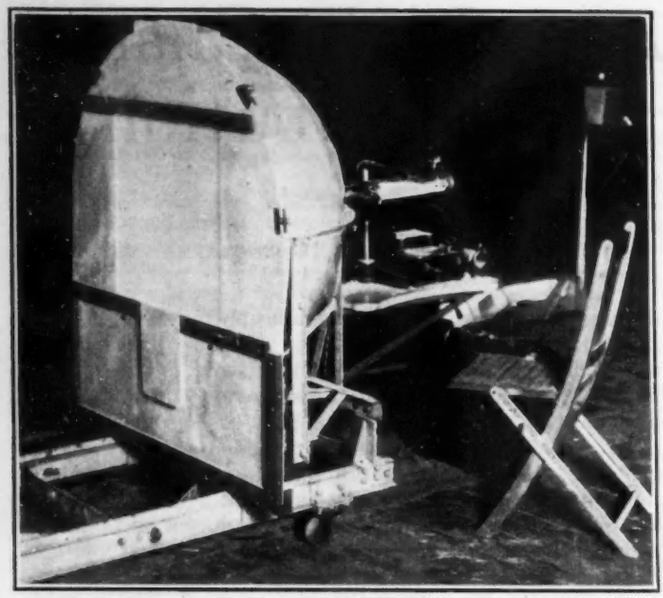


FIG. 2—ONE-METER HEMISPHERE HAVING PHOTOMETER ATTACHED
This Equipment, Including the Franz, Schmidt & Haensch Photometer, Was Used in the Tests

lights to accomplish minimum glare. Such adjustments mean that the most intense light strikes the road comparatively near the car, thereby diminishing the visibility at long range and resulting in a most unsatisfactory and dangerous driving-light.

HEADLIGHT ADJUSTMENT

It has been demonstrated that headlights glare if they are adjusted for range and that when adjusted for nonglare they have no range. In a paper presented on April 2, 1925, at a meeting of the German Illuminating Engineering Society, Dr. Otto Reeb analyzed the German and the American automobile-headlight practices, stating that the American illuminating engineers have tried to solve the difficult problem of automobile headlighting by combining contradictory requirements; first, to give the driver as much light as possible and, second, to avoid glare for the occupants of approaching vehicles. This is precisely what we have been trying to do. Dr. Reeb concludes that the German method is better; adding:

> It was found, for instance, that electric headlights of 20 watts (40 Hefner units or 36 international cp.), having moderate power, do not cause glare when the axis of the projector is inclined in such a manner that the center ray intersects the road within 30 m., (98.5 ft.) of the car. In the case of the stronger lamps, that is, 35 watts (70 Hefner units or 63 international cp.), the beam must meet the road within 15 m. (49.2 ft.) of the car.

Therefore, it is evident that the Germans are using lamps of higher candlepower but are doing precisely what our automobile adjusters are doing; that is, deflecting the beams to avoid glare until they have no range, without regard to the allowable limits of the specifications of the Illuminating Engineering Society or those of this Society.

Ever since the first automobile headlight was placed on a car we have adhered very closely to the parabolic reflector or reflectors having similar vertical characteristics. Various types of lens and of reflector have been designed, but they have mainly to do with spreading the light in the horizontal plane with little change in the vertical distribution, making it necessary to set a rather high value at the *C* point, which is on the center line 1 deg. above the horizontal, to bring the most powerful part of the beam a reasonable distance ahead of the machine. We are allowed from 800 to 2400 cp. at point *C*. I consider even the low limits, 800 cp., within the range of glare and, with the best lamps available set at the low limit, the maximum light strikes the road surface between 40 and 60 ft. ahead of the car; when set at the high limit, it strikes between 80 and 100 ft. ahead. This produces a brilliantly lighted area in the foreground which reduces visibility at long range.

HEADLIGHTING TESTS

Recently, I had a series of careful tests made on a number of the best types of approved headlight and lens in use today. The units were set-up in pairs, in operating position as to height and interval, and were tested at a range of 100 ft. with a carefully calibrated 1-m. (39.37-in.) hemisphere having an aperture 21 in. square, corresponding to 1 deg. at the distance mentioned. All the lamps were calibrated carefully and held at proper current-value during the tests. The curves represent the results on one pair of each type of units only, and some variation naturally would exist one way or the other on the average of a number of pairs, but the vertical characteristics remain essentially the same.

The identity of the headlights and lenses used in the tests is designated merely by letter. Some pairs of the types have laboratory ratings around 40,000 or 50,000 cp., maximum. While it is possible, no doubt, to obtain points of these high values under laboratory conditions

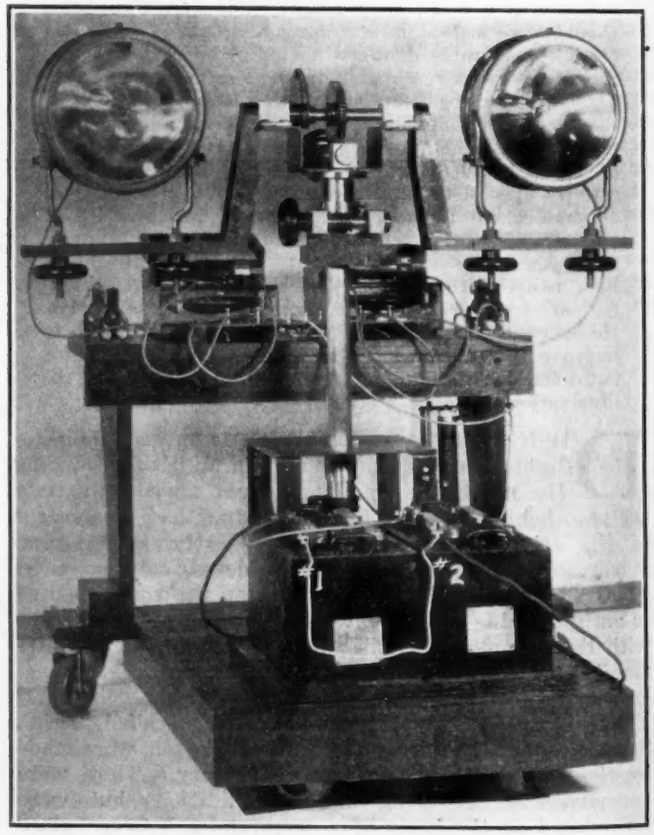


FIG. 3—HEADLIGHT TESTING-STAND
This Apparatus Is Self-Contained and Has Batteries, Instruments and Rheostatic Control. It Enables Very Fine Horizontal and Vertical Adjustments To Be Made

with selected lenses of the first run and super-parabolic testing-reflectors, I believe these values are not attained in practice with the regular commercial equipment; so, apparently, we have been misleading ourselves somewhat as to the candlepower of the automobile headlights in service. These tests demonstrate clearly that, if we are to have range without glare, we must abandon the reflectors of the parabolic type and others of similar characteristic which, after a quarter century of juggling, have proved to be unsatisfactory. The characteristic features will be analyzed later.

"Hot-Spot" of Light for High-Speed Driving

In the last few years a tendency has existed to produce a so-called "hot-spot"; that is, a small central area of very high candlepower for high-speed driving. Unless this hot-spot is projected near the horizontal, where it would produce blinding glare, it is of no great value and, if turned down so as to minimize the glare and come within the legal requirements, it produces a new source of dangerous glare from the oil-polished road-surfaces and is especially pernicious on wet nights. It becomes a secondary source of discomfort, in some cases more dangerous than the direct glare from the lamp, owing to the lower angle from which it is projected into the approaching driver's eyes.

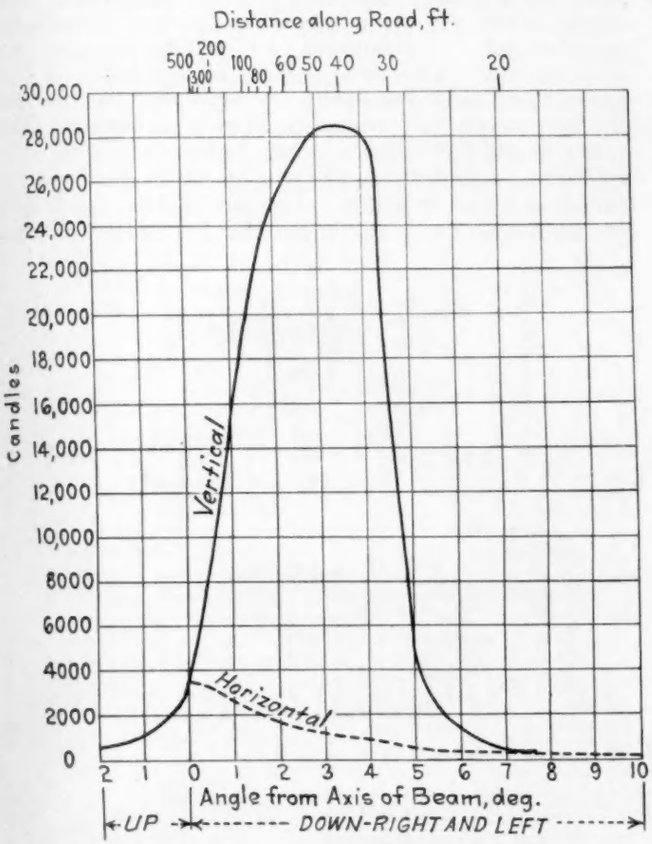


Fig. 4—Vertical and Horizontal Characteristics

On the Pair of Units, Letter *A*, It Will Be Noted That They Give Approximately 28,000 Cp., Maximum, As Indicated by the Solid Line. With These Lights Adjusted for 1000 Cp. and Projecting to the *C* Point on the Center, 1 Deg. above the Horizontal, the Maximum-Candlepower Beam Will Intercept the Road Surface Approximately 40 Ft. Ahead of the Car

In his excellent and constructive paper on Improved Automobile Headlighting[2], Alfred W. Devine, engineer in charge of equipment section, Massachusetts Registry of Motor Vehicles, brings out the following points:

> In attempting to solve the headlighting problem we must have in mind, at each step, the two primary objects which must be attained insofar as it may be practicable, sufficient illumination ahead for safe operation and freedom from dangerous headlight glare for other users of the highway.
>
> The perfection of the beam-distribution characteristics of automobile head-lamps for average use has been handicapped by the rapid change which has taken place in traffic conditions during the last few years and also by a lack of proper understanding on the part of the manufacturer as to what a head-lamp should be called upon to do. *Modern traffic conditions, except in infrequent cases, do not permit excessively high speed on*

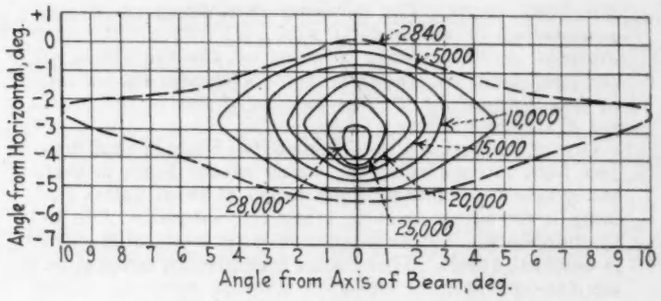


Fig. 5—Isometric Chart of the *A* Units

The Maximum Spot of 28,000 Cp. Subtends an Angle of 1 Deg., Horizontally. This Will Produce a Spot on the Road Only 21 In. Wide at 100 Ft. or 42 In. at 200 Ft. and Is Altogether Too Small To Be of Any Great Value

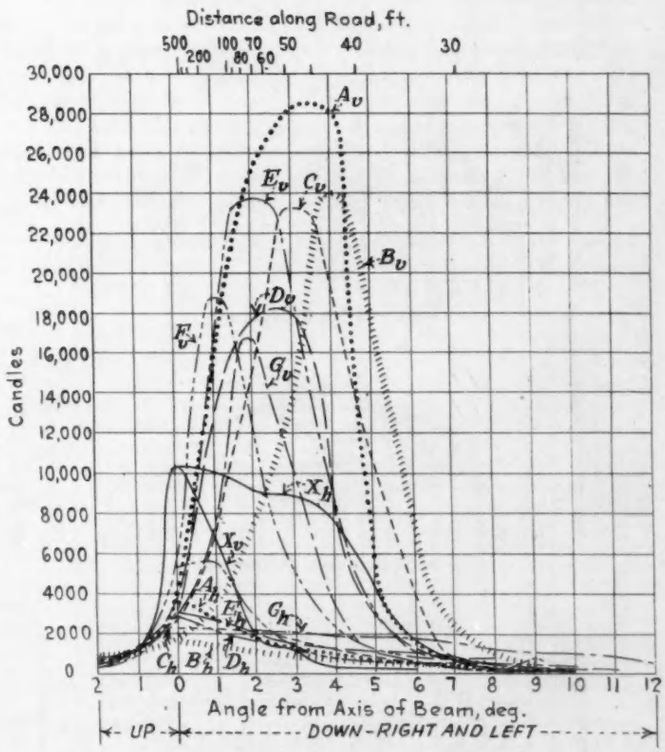


Fig. 6—Vertical and Horizontal Curves Combined

This Drawing Is a Combination of All the Vertical and Horizontal Curves in the Comparison with the Different Units Set for 1000 Cp. at the *C* Point, Which Is Only 200 Cp. above the Maximum of 800 Cp. Allowed at Point *C* by the Specifications. With This Setting, All the Lamps Equipped with Parabolic Reflectors *A*, *B*, *C*, *D*, and *E* Project Their Maximum Beams at an Angle That Will Intercept the Road Surface Anywhere from 35 to 75 Ft. Ahead of the Car, Which Is Altogether Too Close for a Good Driving-Light. Units *F* and *G*, Which Are Not of the Parabolic Type, Show Improved Range with This Setting. Units *X* Have, if Anything, More Range Than Is Desirable

[2] Presented at the 19th Annual Convention of the Illuminating Engineering Society, Detroit, Sept. 15, 1925.

our State roads. The necessity then for great beam-penetration is not present and even though it were desirable to have strong penetration, the usefulness of the head-lamp on congested State highways should not be handicapped by the distribution of flux in the beam for a special purpose.

One of the greatest objections to head-lamps that project high intensities in the center of the beam is that the greatest advantage is not taken of them unless the lamp is aimed up so as to bring this intensity close to the horizontal. Under these conditions intolerable glare is bound to result. There is an ever-present temptation for the operator to tilt such a lamp upward. This temptation is reduced or eliminated when a reasonable limit is placed on the maximum.

I see no reason that anything beyond 20,000 cp., maximum, is required, and half this candlepower would be sufficient in a well-balanced light.

Side Illumination and Depth of Beam

It is desirable that the main beam have a good lateral spread so that it will cover for a considerable distance not only the road but also the ditches. The beam should have reasonable depth so as to carry a gradually diminishing illumination well back to within say 20 ft. of the car. It should be of such a character that it will illuminate the wheels and the running-board of the approaching car clearly at a distance of at least 200 ft. without projecting any direct rays into the eyes of the approaching driver. The majority of the headlights have a sharp horizontal cut-off ranging from 6 to 15 deg. on either side of the center line, which leaves a dark area on both sides of the car for a considerable distance, making it difficult to see the ditches or to judge the passing space available for other cars or to see pedestrians who step into the line of travel at short range. Light in this area is fully as important as light in any other section, and should be of sufficient intensity so that the side of the road or near-by ditch is clearly visible, and there should be ample light for rounding sharp curves or turning corners independent of the light from the main beam. It also should make the reading of signs on either side of the road possible without the use of spotlights or other auxiliary units. Many motorists today are equipping the right-hand fender with what might be called a ditch light or are adding a spotlight, mounted below the radiator and inclined to the right, showing that there is a strong appreciation for the necessity of good side-light. To compensate further for the defects in the present headlights, a tendency also exists to add hub-lights, courtesy lights and one or more spotlights mounted on the windshield to perform the functions which should be taken care of by a single pair of headlights so as to reduce the amount of lighting

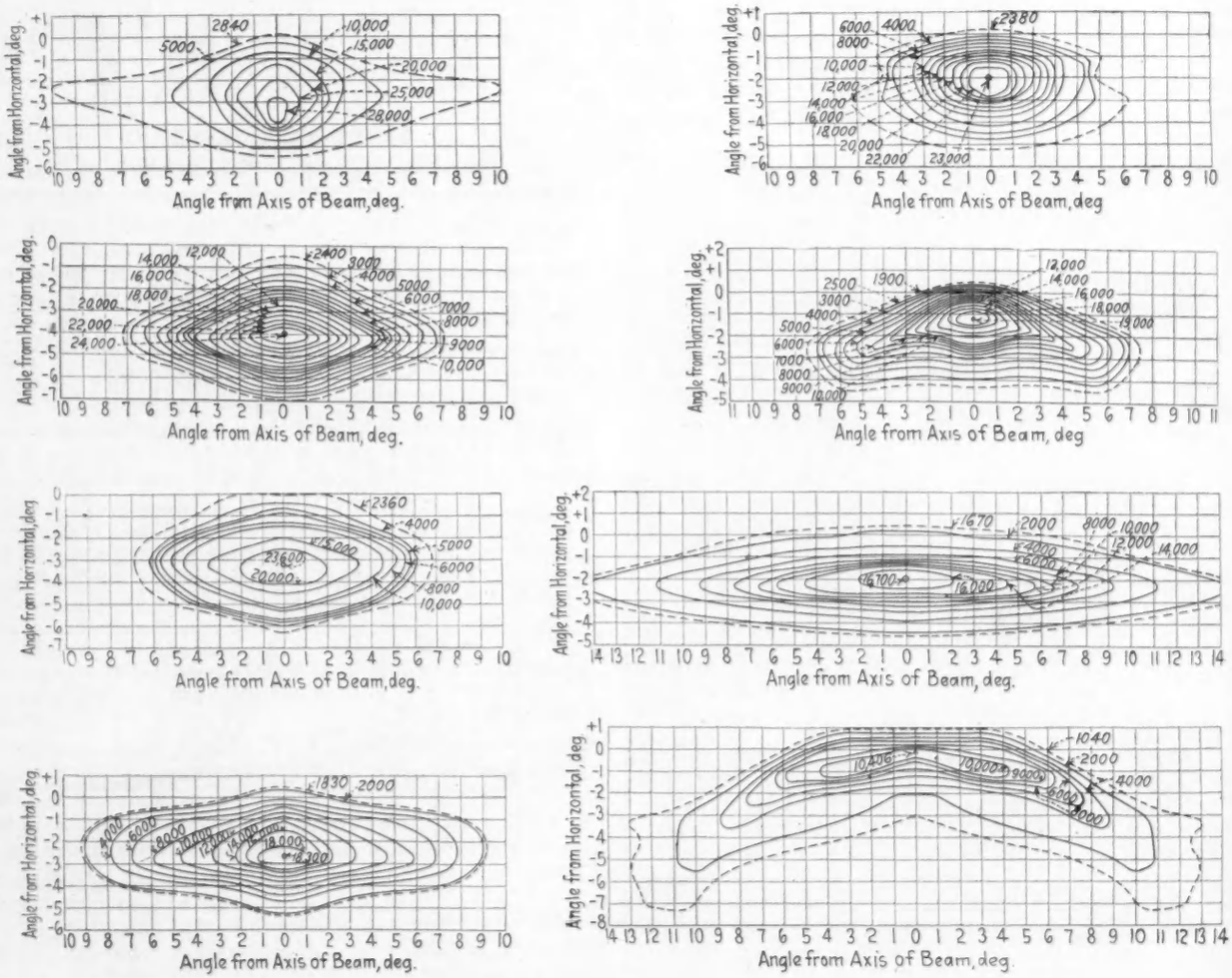


Fig. 7—Combination of Isometric Diagrams

This Grouping Was Made in Order That the Characteristics of the Different Units Can Be Studied Simultaneously. From the Top Down the Order of the Units at the Left Is *A*, *B*, *C*, and *D*. The Units at the Right, Beginning at the Top, Are *E*, *F*, *G*, and *X*

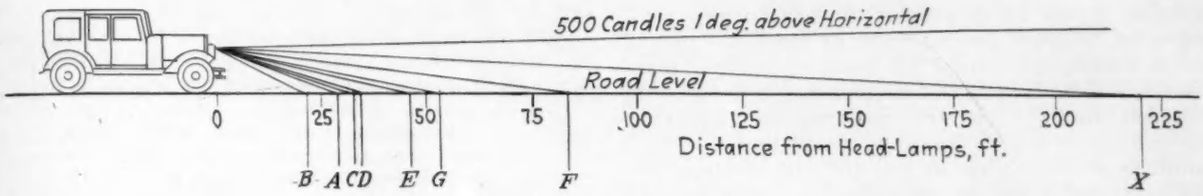


FIG. 9—DISTANCE CHART

This Shows the Distance from the Car at Which the Beams of Maximum Candlepower Strike the Road Surface. With a Setting of 500 Cp. at Point *C*, the Lamps Equipped with Parabolic Reflectors Would Have a Range Varying from 22 to 55 Ft. to the Point of Interception of Maximum Beam on the Road Ahead of the Car. Units *G* Show 55 Ft.; Units *F*, 85 Ft.; and Units *X*, 220 Ft.

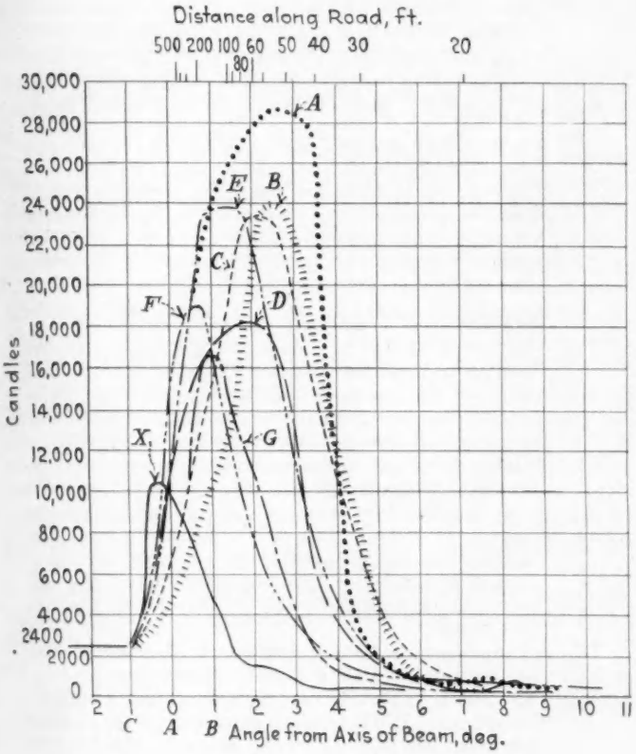


FIG. 8—COMPARISON OF VERTICAL CURVES

This Was Made with the Units All Set at 2400 Cp. at the *C* Point, Which Is the Upper Limit of the Specifications. With This Excessive Permissible Glare, the Range of the Lamps Using Parabolic Reflectors Is Improved, Ranging from 50 to 150 Ft., Which, in the Main, Is Still Too Short, Especially for High-Speed Driving

equipment on the car and the current-drain on the battery.

SIMULTANEOUS CONTRAST

Sufficient light should be provided on the front of the machine—the fenders, the wheels and the radiator—so that in case one light fails an automobile cannot be mistaken for a motorcycle. In conjunction with the light at the sides and immediately in front of the car, this illumination reduces, by simultaneous contrast, the glare effect. Again quoting Dr. Otto Reeb:

> Measurements made by Gehlhoff and Schering dealt with the influence of the general illumination on the glare phenomena. One should expect that the luminous intensity necessary to cause glare would increase with an increase in the general illumination. With no general illumination at a distance of 100 m. (328 ft.), 2000 Hefner units (1800 cp.) will cause unbearable glare, while with a general illumination of 1 lux (0.1 foot-candle) the same effect is obtained only at 20,000 Hefner units (18,000 cp.) . . . . .

In other words, if two bright spots shine toward a driver out of darkness, approximately 10 times as much glare effect exists as if these lights shine out of an illuminated field of relatively low intensity. A careful study of this phenomenon undoubtedly would be of great value.

FOG PENETRATION

Just so long as strong reflected rays that illuminate the fog particles intervening between the driver and the point he is trying to see are thrown above the horizontal, difficulty is bound to be encountered and the best the driver can do is to feel his way along, having no idea as to his position on the road. The remedy is to eliminate all high-power reflected-rays between the observer's point of vision and the distant point he is trying to see and, at the same time, to supply sufficient side and local illumination so that, no matter how dense the fog is, he will always know his exact position on the road.

DIMMING, TILTING REFLECTORS AND TWO-FILAMENT LAMPS

I am inclined to believe that all those who have studied the dimming problem carefully are convinced that dimming is a most unsatisfactory and dangerous practice. The light is cut-off at the critical moment and the eye has no chance to recover before passing the approaching car and into the danger zone. Manually operated tilting reflectors have been tried without much success. This may have been due partly to the fact that so few of them were in use, and the relief from glare offered the

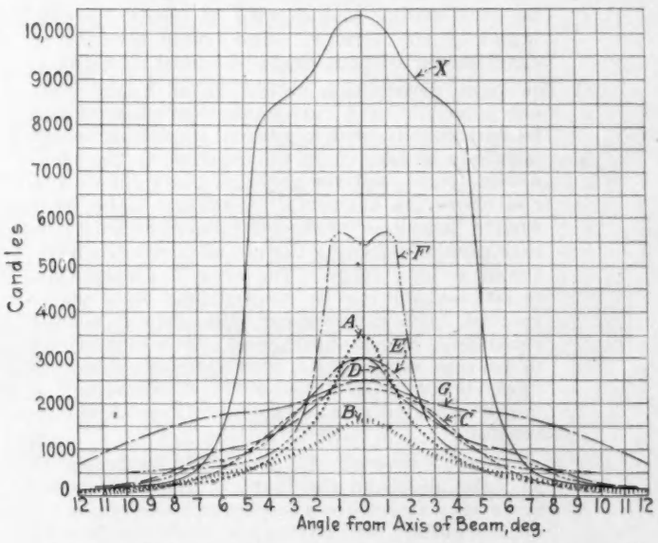


FIG. 10—INITIAL-CANDLEPOWER DISTRIBUTION IN A HORIZONTAL PLANE

With All the Lamps Set for 1000 Cp. at Point *C*, Which Is within the Present Permissible Limits, the Maximum Illuminations on the Horizontal Ranges, for Units with Parabolic Reflectors, Vary Approximately from 1500 to 3500 Cp., Running As High As 5500 Cp. for Units *F*. With This Setting, Unit *X* Projects Its Maximum Intensity of 10,000 Cp. on the Horizontal and Maintains a Relatively High Value for Several Degrees to the Right and to the Left from the Center

approaching driver by depressing the beam rarely could be answered, because the majority of machines had no means of responding except by dimming, which many consider too hazardous a chance to take. I believe the two-filament lamp, if put into use rapidly and extensively, will do much to improve the situation. With the millions of headlights in use and the millions that will go into service before any radical changes in headlights of improved light-characteristics can be put into production on a large scale, it is necessary to do something and that without further loss of time. The success of the two-filament lamp will depend, in a great measure, upon the reasonable response of the public in its proper use. As with the tilting-reflectors, we cannot expect 100 per cent relief but, if we persuade say one-third of the operators to use them with discretion it will make a vast difference in the comforts of night driving. The results obtained with the two-filament lamps are vastly superior to dimming and most likely will result in bringing about the repeal of dimming laws in the few States in which they are now in force.

The headlights of the future should have range without dangerous glare and should not require tilting, dimming or any other form of manual operation; but, until such units are widely in use, we should use every possible means to bring about the equipping of new headlights and those in service with any meritorious feature that will assist in taking the curse out of night driving. I wish to repeat the conclusions of my discussions at the meetings of the Metropolitan and the Detroit Section of this Society. It is not difficult to design a headlight to suit the man behind the steering-wheel, but it becomes a difficult problem when the other driver who faces the lights is taken into consideration. It is right here that the majority of the headlights fail today and, before an automobile headlight can take its place as a decided improvement over the existing equipment, it must meet the following specifications:

Specifications for Improved Headlights

(1) It must be a non-glare unit having a range between 200 and 300 ft. on a level road; it should be non-focusing and capable of operating with lamps of any form of concentrated filament or candlepower without change of focal adjustment

(2) The light distribution should be of fairly wide characteristic with reasonable depth and should be homogenous, with a gradual increasing intensity from a point near the machine to the most distant point, and the reflected beam should not rise above the horizontal. Sufficient light from even a macadam road-surface always exists to take care of softening the cut-off above the horizontal at long range. The area of greatest intensity should not be concentrated in a small spot of high candlepower, but should have a reasonable lateral-divergence. It is important to bear in mind that a very intense spot, particularly on a wet road-surface, introduces a new element of glare, reflected, which should be avoided

(3) A reasonable amount of light should be projected at right angles to the plane of the main beam and even a few degrees to the rear, so as to light-up the gutters and curves and make turns safe in difficult places, and making possible also the reading of road signs on either side without the use of spotlights or other auxiliary lamps

(4) Sufficient light should be thrown on the front of the machine—the radiator, the forward wheels and the bumper—so that they are clearly visible and if one light fails, there should be no chance of mistaking an automobile for a motorcycle. The cut-off of the beam should be such that there will be no upward high-candlepower rays to scatter in the fog and reduce visibility

(5) A general dispersion of unreflected light should be provided to illuminate trees and telegraph poles and give general vista without glare, so that distance can be judged at night as well as in daylight driving. If the non-glare feature of the unit is improved further by lighting-up the front of the machine and the general surroundings, the intensity of the source becomes less brilliant by simultaneous contrast. Further, the main beam should be of a nature such that it will become even less brilliant as the car is approached, which, in turn, will improve the ability of the approaching driver to see beyond the approaching car at the critical moment, and in other ways add a sense of comfort or feeling of security in driving

(6) The lights should be focused definitely for city and for country driving so that there is no necessity for dimming, tilting or other manual operation which, in the majority of cases, with the present increased automobile traffic, is impracticable unless operated at the low point most of the time, except in country driving

Mechanical Headlight Specifications

(1) The lamps should be adaptable to modification of design to meet the aesthetic lines of the car and embody the elements of true art which, at a glance, suggest that the unit is primarily a functioning light-source rather than a decoration

(2) A lamp must be sufficiently rigid in construction so that it cannot get out of adjustment easily

(3) It should be dust and rainproof and a simple means of opening the door should be provided so that the replacement of the lamp or the cleaning of the reflector can be done without the use of tools, unusual exertion or disturbing the adjustment

(4) A simple means for adjustment of the beam should be provided which will not require the bending of forks, difficult manipulations or technical knowledge; in fact, the means should be so simple that anyone can make the adjustment and that little excuse will exist for failure to comply with State or with police regulations

(5) The headlights must be produced at a cost that will not make them prohibitive, even for the low-priced cars, and should not be subject to wide variation in production

I believe the above specifications are well within the range of possibility and can be met without insurmountable mechanical or optical difficulties and at reasonable manufacturing cost.

Fig. 1 shows a section of the 155-ft. searchlight-testing range in the illuminating engineering laboratory of the General Electric Co., Schenectady, N. Y., where extensive automobile-headlight investigations have been conducted in the last 3 years. Fig. 2 illustrates a 1-m. (39.37-in.) hemisphere, having a Franz, Schmidt & Haensch photometer attached, which was used in the tests as described. Fig. 3 is a self-contained headlight testing-stand, having batteries, instruments and rheostatic control. This apparatus enables very fine horizontal and vertical adjustments to be made.

Five pairs of the standard headlights now in general use, equipped with parabolic reflectors, were selected and tested for this paper and they are designated as units *A*, *B*, *C*, *D*, and *E*. Two pairs of head-lamps now on the market having reflectors differing from the parabolic type are included under letters *F* and *G*. These are com-

pared with a pair of experimental lamps embodying improved characteristics designed to increase the range and, at the same time, to reduce the glare and provide adequate side-light. Letter *X* has been assigned to these units.

Analyzing the first vertical and horizontal characteristics on the pair of units, letter *A*, Fig. 4, it will be noted that they give approximately 28,000 cp., maximum, as indicated by the solid line. With these lights adjusted for 1000 cp. and projecting to the *C* point on the center, 1 deg. above the horizontal, the maximum-candlepower beam will intercept the road surface approximately 40 ft. ahead of the car. It will be observed further that with this setting the maximum candlepower on the horizontal is approximately 3500 cp., falling off rapidly to the right and to the left. This low intensity on the horizontal is made less effective by the brilliantly illuminated patch of light striking the road surface a short distance ahead of the car.

Fig. 5 is an isometric chart of units *A*. The curves have not been carried beyond 10 per cent of the maximum, which is the vanishing point of the line of demarcation one observes in looking at a projected beam. As this is sufficient to show the general characteristic, it did not seem necessary to project the curves any farther. The maximum spot of 28,000 cp. subtends an angle of 1 deg. horizontally. This will produce a spot on the road only 21 in. wide at 100 ft. or 42 in. at 200 ft. and is altogether too small to be of any great value, also having the objections of causing too sharp a contrast to the rest of the beam. Even if this so-called hot-spot were wider, it is situated with reference to the vertical so that it could not be brought up to the long-range position, which would require an elevation of about 3 deg., without projecting intolerable glare at the *C* point.

Referring to units *B*, *C*, *D*, and *E* (Fig. 6), considerable variation in the general distribution of the different units is evident and some modification in the vertical characteristics, but not so much but that the previous remarks apply to all. Units *F* show a step in the right direction by departing from the parabolic reflector, which results in an increase in range and some modification in the horizontal distribution. Units *G* contain reflectors having a slight modification in the vertical and a wide modification in the general distribution, with resultant increase in range and improvement in cut-off. These are the most efficient units in beam lumens so far tested. It will be noted, however, from the isometric chart, that a considerable amount of this light is thrown far beyond the sides of the road, where it is wasted. It would, therefore, be better if this stray light were utilized in giving greater depth of beam from the maximum down, so as to illuminate farther back toward the car.

Units *X* show a considerable departure in light characteristics from standard headlight-practice, not only in the vertical and in the horizontal distribution but in the general character of the field. For a setting of 1000 cp. at point *C*, the maximum light can be projected on the horizontal. It will be observed further, by studying the line X_h, that the horizontal candlepower which coincides with the maximum is retained at relatively high value for a considerable distance to the right and to the left from the center in place of starting at low candlepower and falling-off rapidly, as shown in the curves of the other units. A study of the isometric chart in the lower right corner of Fig. 7 reveals that the general distribution takes the form of a curve so as to follow the vanishing point of the road, thereby utilizing what otherwise would be stray light for the illumination of the sides of the road and ditches well up to the car. This also avoids flashing light of high candlepower into the eyes of the approaching driver in rounding curves. Another feature of importance is the wide dispersion of the maximum-candlepower area. This makes it possible to cover the entire road at long range

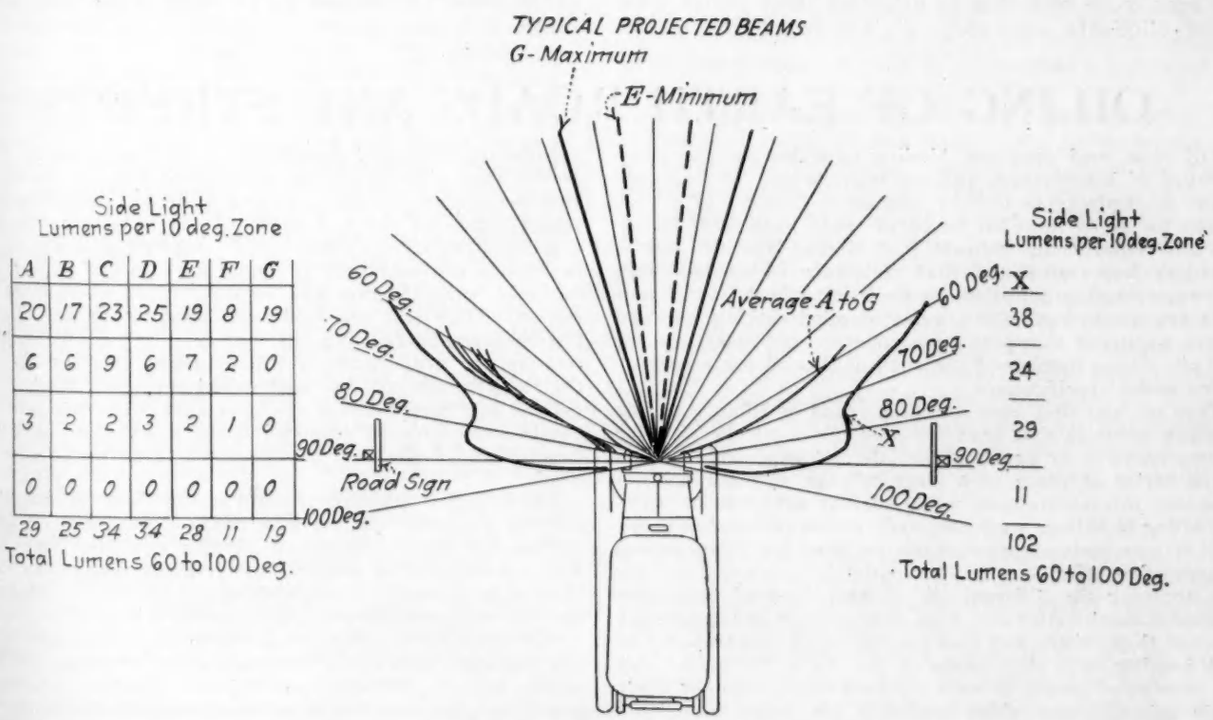


FIG. 11—SIDE-LIGHT COMPARISON

The Efficiency in Side Illumination of Units *A* to *G* Inclusive Is Shown. If a Headlight Is To Perform All the Functions Required for Safety, Side Illumination Must Be Given As Much Consideration As Range and the Elimination of Glare

with the strongest light and permits a reasonably sharp horizontal cut-off following, as near as possible, the crown of the road.

Fig. 6 is a combination of all the vertical and horizontal curves in the comparison with the different units set for 1000 cp. at the *C* point, which is only 200 cp. above the minimum of 800 cp. allowed at point *C* by the specifications of the Illuminating Engineering Society and those of this Society. With this setting, it will be noted that all the lamps equipped with parabolic reflectors *A*, *B*, *C*, *D*, and *E* project their maximum beams at an angle that will intercept the road surface anywhere from 35 to 75 ft. ahead of the car, which is altogether too close for a good driving-light. Units *F* and *G*, which are not of the parabolic type, show improved range with this setting. Units *X* have, if anything, more range than is desirable.

Fig. 7 is a combination of the isometric diagrams of the different units in order that their characteristics can be studied simultaneously.

Fig. 8 is a comparison of the vertical curves with the units all set at 2400 cp. at the *C* point, which is the upper limit of the specifications of the Illuminating Engineering Society and those of this Society. With this excessive permissible glare we find the range of the lamps using parabolic reflectors improved, ranging from 50 to 150 ft. which, in the main, is still too short, especially for high-speed driving. Units *F*, with this setting, show a range of approximately 250 ft., and units *G* about 160 ft., while units *X* project the light altogether too high. With an initial setting of 2400 cp. at point *C*, the deflection up of 1 or 2 deg., due to road inequalities, car loading or for other reasons, would cause the projection of light in line with the approaching driver's eyes of anywhere from 10,000 cp. for units *X* to 24,000 cp. for units *A*. Under these conditions the elimination of glare, no matter what type of unit is used, is physically impossible. Ultimately, the candlepower limits at point *C* must be reduced. It can readily be seen that to establish these limits today would eliminate practically all the headlights on the market. As it is, they all give glare without satisfactory range when working within the present allowable limits.

Fig. 9 shows clearly that, with a setting of 500 cp. at point *C*, the lamps equipped with parabolic reflectors would have a range varying from 22 to 55 ft. to the point of interception of maximum beam on the road ahead of the car. Units *G* show 55 ft.; units *F*, 85 ft., and *X* units, 220 ft. I think that almost anyone will agree that headlights having a range of less than 100 ft. for the maximum illumination would be the cause of just as many accidents as glare would cause.

Fig. 10 shows that with all the lamps set for 1000 cp. at point *C*, which is within the present permissible limits, the maximum illuminations on the horizontal ranges, for units with parabolic reflectors, vary from approximately 1500 to 3500 cp., running as high as 5500 cp. for units *F*. Unit *X*, with this setting, projects its maximum intensity of about 10,000 cp. on the horizontal and maintains a relatively high value for several degrees to the right and to the left from the center.

Fig. 11 shows the efficiency in side illumination of all existing headlights, units *A* to *G* inclusive. *If a headlight is to perform all the functions required for safety side illumination must be given as much consideration as range and the elimination of dangerous glare.*

In making the foregoing comparisons it is not my intention to assume that the experimental headlights, units *X* are the final solution of the problem. They are probably too far in advance of the times and may have to be led up to by degrees. Further improvements undoubtedly can be made; nevertheless, the various points herein covered indicate a general direction in which we can work to relieve the present automobile-headlight situation, and while some of the present candlepower limitations stand in the way of improved design, it is to be hoped that, when improvements are demonstrated clearly, the laws will be modified as to the point-*C* values and even to the extent of allowing lamps of higher candlepower, if necessary, to bring about the desired result.

OILING OF EARTH ROADS AND STREETS

FOR most road purposes, binding qualities and the properties of adhesiveness and cementitiousness are regarded as the determining factors in judging the quality of a road oil, but for an oil intended for earth roads, experience in Illinois and experiments indicate that binding qualities are of secondary importance and that resistance to emulsification and waterproofing qualities are more important. In Illinois there are upward of 10,000 miles of oiled earth roads and streets requiring annually approximately 45,000,000 gal. of road oil. For a number of years all of this oil has been purchased under specifications.

When oil was first used on earth roads in Illinois, it was naturally assumed that asphaltic-base oils would be superior to semi-asphaltic or paraffin-base oils, but experience gained over a period of years on a large mileage of roads has not borne out this assumption. The earliest attempts at earth road oiling in Illinois were primarily a dust preventive measure. It was soon observed, however, that the oil produced waterproofing effects.

In applying the different oils it was observed that some penetrated much better and were more quickly and completely absorbed than others and that the degree of penetration had much bearing upon the success of the oils on the road. Oils that penetrated poorly or were not completely absorbed made a thin skin-like mat which tended to pit under traffic and make a rough non-uniform wearing surface. The oils that penetrated best invariably developed the best wearing surface and gave the least trouble in applying.

Semi-asphaltic and paraffin-base oils are superior to asphaltic-base oils for use on earth roads for the reason that they resist emulsification and retain their life much longer in contact with the soil and moisture. Reduced pressure-tar is a satisfactory oil for earth roads. Binding qualities and adhesiveness are secondary in importance to the ability of oil to resist emulsification and retain its life in contact with the soil. This may not hold true in extremely dry climates. Cut-back or mat-forming oils that develop their asphalt content by the evaporation of their lighter constituents after their application are not well suited for earth roads. Non-volatile and homogeneous oils penetrate better and are more evenly and uniformly absorbed by the soil than blended products. Blended oils tend to separate or fractionate when applied.

The so-called "asphalt or solid residue test" is unsatisfactory as a control test or as a basis of purchase or specifications for semi-asphaltic or paraffin oils for earth roads. The test may be of some value from the standpoint of the chemist as a means of establishing the identity of characteristics of unknown products, but beyond this is of no value.

The foregoing conclusions are based on tests made on specific soils in Illinois. Different soil or climatic conditions might lead to different conclusions. Surface treating of gravel or macadam roads presents entirely different problems and entirely different materials may be denoted for this.
—From a paper by F. L. Sperry presented at the annual meeting of the American Society for Testing Materials.

An Electric Drive for Gasoline-Propelled Motorbuses

By HENRY S. BALDWIN[1]

SEMI-ANNUAL MEETING PAPER

THE discussion following the presentation of this paper at the 1925 Semi-Annual Meeting was chiefly oral, although some written contributions were subsequently received. In accordance with the usual practice, these discussions have been submitted to the various speakers for their approval and to the author for any additional comment that he cared to make. The corrected discussion, as received, is printed below. An abstract of the paper precedes the discussion so that those of the members who did not read the paper when it was printed in the July, 1925, issue of THE JOURNAL can gather some knowledge of the subjects covered by reading the abstract if they do not wish to read the complete text.

This completes the publication of the discussion of papers presented at the 1925 Semi-Annual Meeting.

ABSTRACT

DEVELOPMENT of the uses of electricity having begun approximately three decades ago, about the time that the automobile made its appearance, the application of electricity to the needs of the automobile has enabled manufacturers to meet the demands of the public for its production. When electricity was applied to starting the internal-combustion engine and to lighting the automobile 15 years later, the popularity of the automobile greatly increased. Now, 5 per cent of the weight and nearly 10 per cent of the selling price of a five-passenger sedan represent electrical apparatus that adds to the comfort and convenience of the public.

Inasmuch as practically all transportation of passengers in cities and suburbs during this period has been carried on by electric street-railways, they have reached a high state of development and efficiency, and the experience of the companies with electric motors has established great confidence in their reliability and durability under all conditions of service. Realizing that new conditions have arisen, the public utility companies now look to the motorbus to act as a feeder to their lines and to relieve the pressure of traffic by utilizing boulevards and highways on which rails and trolley wires are not permitted.

Beginning with a description of the first application of the electric drive to motorbuses in this Country in an experimental single-deck vehicle operating on Fifth Avenue, New York City, in 1904, the author follows the course of its progress up to the present time. In 1908, 10 electric-driven motorbuses were placed in operation and continued over that route for 6 years, together with similar DeDion coaches equipped with mechanical drive. In 1909, 25 additional mechanically driven motorbuses were ordered because they were available, whereas those of the electric-driven type, although they had proved successful, were not yet in regular production.

Having been tried in motorbus service, the electric drive was then extended to railroad passenger cars; later, in connection with Diesel engines, it has been applied to ship propulsion, and, more recently to oil-burning locomotives. In England, out of more than 1300 electric-driven motorbuses built by the Tilling-Stevens organization, 460 were put into service in the London General Omnibus Co.

A modification of the electric-drive system in which all the electrical energy passes directly through the driving-motors has been recently devised by Prof. Morton Arendt, of Columbia University, and includes a storage-battery. Illustrations and wiring diagrams of this and of numerous other systems are shown, including the Yellow Coach motorbuses in use by the Philadelphia Rural Transit Co., of Philadelphia, the Fageol Motor Co. motorbuses used by the Capitol District Transportation Co., of Albany, N. Y., and the single-deck White chassis operated by the Northern Ohio Traction & Light Co.; and space is given to a discussion of the advantages of the electric over the mechanical drive.

THE DISCUSSION

CHAIRMAN G. A. GREEN[2]:—It seems evident that, from the point of view of accident hazards, the gasoline-electric vehicle has distinctive merit. For example, a driver can concentrate on his work much better, when operating the gasoline-electric drive, than when it is necessary to release the clutch to change gears. The operation is smooth and free from jerks, which are very difficult to avoid with the conventional gearshift and clutch; and the quietness factor cannot be ignored because excessive gear-noise may effect the mental condition of passengers to a point at which a relatively small occurrence assumes an unnecessary degree of importance.

In considering possible economies in connection with motorcoach operation, the major issue is the wages paid to drivers and conductors. Taking the case of the double-decked motorcoach, the platform cost per mile for a two-man-operated vehicle is approximately $0.12. To appreciate the importance of this expenditure, it should be mentioned that this item is about twice that of the total mechanical fixed-charges, namely, gasoline, lubricating oil, labor, and material for the maintenance of the chassis, body, tires, and the like. Consequently, it will be seen that one very simple method of reducing expenses is to increase the safe vehicle-speed. It seems reasonable to suppose that, if the gear-shifting operations are eliminated, improved acceleration will result, a controlling factor from the point of view of additional speed.

The improvements in operation, as outlined above, represent merely my personal opinion, the correctness or incorrectness of which will be demonstrated definitely by the operation of the Philadelphia motorcoaches, which we shall all watch with interest.

E. H. LAMBERGER[3]:—The luxurious finishings, flexibility and convenience that the automotive engineer has worked into the automobile has had a very decided influence on the adoption of the motorbus for general transportation. The very best is demanded in the motorcoach just as it is in the automobile. The adaptation of

[1] M.S.A.E.—Engineer, automotive department, General Electric Co., Lynn, Mass.

[2] M.S.A.E.—Vice-president, Yellow Coach Mfg. Co., Chicago.

[3] Railway section, general engineering department, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

the gasoline-electric drive to the motorcoach is along this line.

The various characteristics of the electric drive appeal to different groups that are interested in the motorbus. Smooth acceleration and the elimination of gear-shifting and noise appeal to patrons; the long life of the apparatus and familiarity with this type of apparatus appeal to the railway operator; certain factors, such as the possibility of lower engine and vehicle maintenance, longer engine and vehicle life, and the adaptability of the coach to one-man operation appeal to all operators. The elimination of clutch manipulation and gear shifting reduces the demands on the driver's attention and therefore results in safer coach-operation and more complete and courteous service to patrons.

It is only reasonable to expect that, in a new device like this, many schemes should be proposed. Any scheme, to endure, must have certain fundamental characteristics. It must have the minimum weight of apparatus consistent with the capacity required for the service to be performed; the minimum amount of apparatus consistent with what is to be accomplished; and simplicity of control. The last-mentioned characteristic is very important and is the cause of many proposed schemes' falling by the wayside.

Considerable development of electrical and mechanical apparatus for a satisfactory gasoline-electric drive has already taken place. Much of the experience gained in connection with servicing motors on street-railway cars and on electric trucks is of value in this case. The inherent characteristics of the series motor lend themselves almost ideally to the gasoline-electric drive. The fact that the powerplant is limited in the motorbus has a very important bearing on the design of the generator. The method of excitation, the characteristics of the generator, and the electric apparatus as a whole, must, of course, be suited to the present characteristics of the gasoline engine. Before a final solution has been reached, it may be found possible and necessary to obtain somewhat different engine-characteristics.

As pointed out, it is necessary to have a drooping generator-characteristic in order to prevent stalling the engine under any load conditions. The generator must have a quick pick-up to prevent engine racing and to minimize the lag in vehicle pick-up. The use of separate exciters should be avoided, as it means the use of more small parts. It adds a complete armature, a complete set of brushes, a commutator, and so on, all of which increase maintenance and inspection and add to the complication.

The installation that has been described is the first one of sufficient size in this Country so that the results obtained will be conclusive, at any rate along certain lines. Many novel installations like this one suffer from the fact that they are begun on a very small scale, so that the results are not always representative of what would be obtained under normal operating-conditions. In this case, we have a sufficient number of motorbuses in operation so that the data obtained over a period of 1 or 2 years should be very valuable. It will be interesting to note the performances of this equipment, because it is certainly of the latest design and much has been done to get low weight and good operating-characteristics. It will also be interesting to note the results of its performance with a continuous torque of approximately one-half that of modern light-weight railcars, and without commutating poles.

Electric braking has possibilities, but, as has been pointed out, it is questionable whether it will ever be used for actual service stops. This is because the air-brake has been very highly developed, and because electric braking throws extra duty on the motors, causing extra heating, and therefore requiring extra capacity in the motors, which adds weight. Since it is necessary to keep the weight to the minimum, there is a question whether this type of braking will be advisable for regular service use.

Probably one of the most important factors that caused the use of two motors instead of one is the need of keeping the floor height to the minimum while still having sufficient clearance under the motors. A single motor allows the use of a standard automotive rear-end; but this can also be used with a two-motor equipment, when the wheelbase is sufficient for the motors to be mounted in tandem and the drive to the rear end to be through a single shaft.

The gasoline-electric drive has unquestionable merit for severe city service. Considerable experience will be required to determine over how broad a field its application can be economically justified.

E. C. Wood[*]:—We have been making experiments on motorbuses of this type on the Pacific coast and have been trying to determine the number of man-hours required to keep a vehicle on the streets, that is, the number of man-hours required for the various component parts. We have found in that analysis, that the transmission and the rear-end groups are responsible for a considerable amount of time and material.

Our experiments with the electrical vehicle show that a great deal of work remains to be done. The grades on the Pacific coast range from 3 to 35 per cent; but we operate electric vehicles with success that vary in capacity from 0.5 to 5.0 tons, and 6.5-ton low-bed trucks. These are not new to the East, but they are to us in the West. Many mistakes were made at first, but we have profited by those mistakes, and in future the cost of operating motor vehicles will be materially lessened by using electric vehicles.

Considerable thought should be given to the use of undersized motors, that is, the 60-volt motor, or one varying from 60 to 85 volts; also to the dynamic brake. We have made some experiments that have proved that on our hills a dynamic brake is the least expensive. It requires absolutely no maintenance, the generators being used as motors, and vice versa. Because of road conditions in the West the clearance on the rear end of trucks should be given some thought. I presume similar conditions exist in the East. The right piece of equipment should be purchased for a particular job. A large size coach with an undersize motor will not stand up. It means a great deal of trouble from the points of view of service and general complaint.

J. C. Clendenin:—I have some rather interesting figures on the performance of the gasoline-electric motorbus that are now operating in Philadelphia, particularly with regard to acceleration. Mr. Baldwin and others have emphasized the importance of that feature, which I believe is one of the outstanding characteristics of the gasoline-electric drive as applied to motorbus service.

The factor that develops torque in an electric motor is the current flowing through the armature and fields. In an ideal generator, if we could convert into current all the energy that is available from an engine running at a given speed, we should have the maximum possible torque; and that is the feature which we have accom-

[*] M.S.A.E.—Superintendent of transportation, general shops, Pacific Gas & Electric Co., San Francisco.

plished through the drooping generator-characteristic that is used in this gasoline-electric drive.

The generator is wound with a differential-series field. The voltage developed in the armature of the generator is dependent on the magnetic field that passes through the armature.

If a mechanic has a series field-winding that tends to oppose the normal shunt-field of the generator, and if that bucking action becomes greater as the current increases at the time of starting, or maximum current, the bucking effect on the field will be the greatest, the generator voltage will be lowered, the gasoline engine will build-up to a high speed, and the maximum output will be available in terms of current or motor torque.

The figures that I have just obtained refer to the gasoline-electric motorbuses now in service at Philadelphia. The scheduled speed maintained by them is 11.83 m.p.h., as compared with a scheduled speed of 8.90 m.p.h. by the gasoline direct-driven double-deck coaches. In other words, the scheduled speed has been increased from 8.90 to 11.83 m.p.h.

What does this represent in the equipment necessary to maintain a schedule under a definite headway? On the basis of a 2.1-min. headway at rush hours, it is estimated that on a given route, 66 gasoline-electric coaches will be required. If the same route were equipped with coaches having mechanical drive, it is estimated that, using the figures of scheduled speed which have been obtained from service, a total of 88 coaches would be required.

Assuming for a moment that the cost of one of these mechanically driven coaches is $11,000, the total cost of the equipment would be $970,000. Comparing this cost with that of 66 gasoline-electric coaches at a price of $13,000 each, which is conservative, the total cost of the equipment would be $860,000, a saving in favor of the electric drive of $110,000.

This saving is in equipment alone. Let us now consider the cost of operating the coaches. With the mechanically driven coaches, 8 extra men all day and 22 extra crews at night would be required to man the extra vehicles.

These figures are somewhat general, but I am trying to convey the idea to you that, although the question of cost of electrical equipment is not vital, as Colonel Green and Mr. Baldwin have said, yet the cost of this equipment would probably be more than written off in the saving in operating cost and the increase in revenues due to the higher schedule-speeds.

R. McA. Lloyd[5]:—My objection to gasoline-electric-driven coaches has not been that I did not see their advantage in ease of running and, perhaps, in cost of operation, but I have always felt that the generator is a sort of small neck of the bottle that would not let enough power through. You can overload a motor for a short period and can get a great deal of power out of a small motor but you cannot generate a great amount of power with a small generator.

When I threw up my hands about 10 or 12 years ago, while I was working in cooperation with Mr. Baldwin, it was chiefly because I did not feel that it was possible to get the requisite electric power out of a generator in the way that mechanical power can be obtained from an engine; but I am satisfied that Mr. Baldwin has done it.

C. O. Guernsey[6]:—I had the pleasure of being associated with Mr. Baldwin in the first experimental motorbus, No. 102, to which he referred. Mr. Baldwin has been rather modest with regard to his claims as to the advantages he has achieved. I do not believe he made the point that the engine of the gasoline-electric coach actually turns at about 20 per cent fewer revolutions per mile in city service than does that of the mechanically driven coach.

I criticized the gasoline-electric drive in my paper[7] and would like to point out that, for this particular type of application, the efficiency of the gasoline-electric drive is more than offset by the fact that the engine can be run at substantially a constant speed during acceleration and during service and that, because the engine can be run at a constant speed, it can be operated with the spark-advance in the proper position, with the carbureter in the proper adjustment, and without sacrificing anything to secure the extreme flexibility that is required by a mechanical drive in this class of service.

In the experimental coach, we found it expedient to operate the engine at a considerably higher compression-pressure than was possible with the mechanical drive, and could do so without producing distress of any kind in the engine.

Mr. Baldwin stated that the gasoline consumption was substantially the same. During the tests on motorbus No. 102, the rate of consumption of gasoline with the mechanical drive was 3.84 miles per gallon; and with the electric drive, on coaches that were identical, except that the compression-pressure had been raised and the electric drive was used, it was 4.21.

I think that the real advantages of the electric drive, although mentioned, have not been sufficiently emphasized. A coach is operated for the transportation of passengers. It costs a certain amount to operate the vehicle for a given number of seated passengers. It is the carrying of extra passengers that makes the profit. Smoother acceleration, quietness of operation, and freedom from jerks, jolts and grating noises, contribute a great deal to the comfort of passengers, consequently, the public is satisfied with the service rendered.

Another point that has not been emphasized is quite important, that is, the matter of damage claims. A lady climbs aboard the bus and, by the time she is half-way up the stairs, the operator engages the clutch; she is bumped against the rail, or thinks she is; or is thrown off her feet while going down the aisle. A good deal of dissatisfaction and some actual expense in connection with minor accidents of that kind are entirely avoided with the electric drive. Without actually riding in them, it is not possible to obtain an idea of the extremely pleasant operation of these vehicles. The coaches that have been delivered recently in Philadelphia will afford a ride equal in comfort to that of your own car.

A. J. Scaife[8]:—In his comparison of weights per passenger, why did Mr. Baldwin use the weight of a Pullman car instead of the weight of an ordinary passenger-car? Why have no experiments been made without the flywheel? Is a flywheel necessary to the operation of a gasoline-electric coach?

The weight of the armature, it seems to me, would more than offset the weight of the flywheel. On some of the lighter 24-passenger coaches it seems a crime to take out a 200-lb. transmission and put in 2,200 lb. of material, if doing so could possibly be avoided. Why did Mr. Guernsey provide capacity for climbing 8 or 10-per

[5] M.S.A.E.—Consulting engineer, New York City.

[6] M.S.A.E.—Chief engineer, automotive car division, J. G. Brill Co., Philadelphia.

[7] See The Journal, July, 1925, p. 77.

[8] M.S.A.E.—Chief factory service engineer, White Motor Co., Cleveland.

cent grades on a railroad when the maximum grade is about 3 or 4?

H. S. BALDWIN:—My reason for making the comparison per passenger between the Philadelphia Rural Transit Co.'s motorbus No. 102 and a steel Pullman car was to show the greatest difference that I could find in the number of pounds per passenger. I wished to emphasize as much as possible the very great difference in the weight of vehicles for carrying passengers and, if I remember the figures correctly, the weight of the Philadelphia Rural Transit motorbus per passenger was about 213 lb. as against nearly 5000 lb. for the Pullman car. That was simply an extreme illustration but it applies also to the question of cost.

Answering the question regarding the elimination of the flywheel, we have considered doing so; it is true that the weight of the flywheel can be reduced somewhat when the electric drive is used compared with that used in the regular mechanical drive; but the armature of the generator is so small in diameter that the center of gyration is comparatively close to the center of the shaft, so that the flywheel effect of the armature is not great; and we have found that sufficient steadiness is not given by the armature, at least in a four-cylinder engine. We have not tried the experiment with a six-cylinder engine.

CHAIRMAN GREEN:—I have been obliged to confine myself merely to opinions. I have explained my personal feelings and beliefs with regard to gasoline-electric development in the earlier stages of this meeting.

Frankly, until a year ago, I was skeptical. I am convinced, however, that improvements have been made in gasoline-electric transmission that have placed it far in advance of anything that has been achieved in the past. How good it will be, how successful, how economical, or how the public will like it, I do not know. These are features that the future must unfold; but I am very optimistic, and think that anyone who watches the operation of the vehicles now in regular service will feel as I do. We do not know how much the saving will be, but the future looks interesting.

MR. BALDWIN:—I have a letter signed by R. W. Meade, president of the New York Transportation Co., in which he states that the 10 electric-driven coaches have been entirely successful from an electrical standpoint and that, if he had had the experience with the better engine of motorbus No. 156 with the single drive, he would never have gone abroad for the 25 buses he then ordered in France.

Regarding the weight of the Fifth Avenue buses, the actual difference between the De Dion and an electrically driven machine of the two-motor type was 347 lb. In the case of motorbus No. 156 having a single motor, the difference was 70 lb. in favor of the electrically driven vehicle. This was accomplished by lightening the chassis to a point beyond what Colonel Green would perhaps have considered a safe limit; but nevertheless those are the figures.

CHAIRMAN GREEN:—In conclusion, I desire to pay tribute to the organization that has made possible the carrying out of this development in a large way. Primarily, I am referring to the Mitten Management. If it had not been for the strongly held opinions of Messrs. Mitten, Queeney and Horton, we should not have had, at this early date, an opportunity to prove or disprove the merits of gasoline-electric power-transmission as applied to motorcoaches. In this connection, it should be remembered that, while there is no particular difficulty in the production or manufacture of a comparatively new mechanism such as this, the real stumbling-block is to find a customer with enough courage to purchase a sufficient quantity to provide a real test.

It should also be realized that, up to the present, relatively few minds have concentrated on the problems of gasoline-electrically propelled motorcoaches. I say this with due appreciation of the work done by the General Electric and Westinghouse Companies. The point is, that the sum total of the brains that are working toward the perfection of gasoline-electric equipment is very small as compared with the enormous brain-power that has been applied to the automotive industry generally; yet, in spite of this fact, real progress has been made, and no doubt exists that many further improvements will be made which will decrease the weight and cost and improve the overall efficiency of the electrical equipment.

A. W. SCARRATT[9]:—I have had 9 years of experience in the design, construction, operation, and maintenance of electric-railway equipment and can well appreciate the reliability that is afforded through the use of electric power. It is my belief that the gasoline-electric combination is the ideal power-unit for motorbuses, especially for city work where frequent starts impose such terrific strains on all the units entering into the complete power-generating and transmission system. The gasoline-electric combination affords greater safety, smoother acceleration and greater comfort to the passengers, and less fatigue to the driver and the power-generating and transmission units. From the standpoint of efficiency, I believe that it will compare favorably with the gasoline mechanically driven motorbus even though the odds, theoretically, would be in favor of the mechanically driven vehicle. Personally, I favor the use of an engine and generator of sufficient capacity to make the use of a storage-battery unnecessary.

A. E. HUTT[10]:—To anyone who has operated large fleets of motorbuses the possibilities of the gasoline-electric vehicle are certainly interesting but, as Mr. Baldwin says in concluding his paper,

> The survival of the electric drive, like all other things, depends upon its fitness for the purpose intended. To exist, it must demonstrate its superiority over the mechanical drive under service conditions.

Within the next 12 months, 200 vehicles in Philadelphia equipped with Mr. Baldwin's electric drive will have clearly demonstrated whether this form of drive is to supersede the mechanical drive. If these vehicles can maintain a higher schedule or time-table speed and at the same time reduce the total cost of operation per mile, the addition of about 2000 lb. of weight and $2,000 cost per vehicle will be warranted. Conservative and experienced management, however, will not rush to adopt this type of drive, except possibly for experimental purposes on a very limited scale, until the vehicles have proved their superiority over a period that will embrace all possible climatic conditions, all kinds of routes, and an average mileage of at least 50,000 per vehicle.

J. F. WINCHESTER[11]:—Mr. Baldwin has presented a comprehensive history of the motorbus to demonstrate that the electric-driven type of vehicle is not in an experimental state and will operate efficiently, in comparison with mechanical transmission. My interest in this subject is due entirely to my general interest in transportation subjects insofar as they affect the public

[9] M.S.A.E.—Mechanical engineer, Minneapolis Steel & Machinery Co., Minneapolis.

[10] M.S.A.E.—Ardmore, Pa.

[11] M.S.A.E.—Supervisor of motor equipment, Standard Oil Co. of New Jersey, Baltimore.

welfare, for there is no possibility that the electric type of drive would have sufficient advantage ever to be of value in the type of operation that is under my supervision at present. The paper, therefore, will be reviewed entirely from the standpoint of what is best from a general transportation point of view, rather than from any idea that it might be possible to use it in my present operation.

History, to my mind, does not bear out the idea submitted, that this type of drive is practical and has proved satisfactory for a time; and I regret that greater detail has not been shown along the lines of cost, engineering and service, to substantiate the claim that greater and smoother acceleration is a paying proposition in face of the disadvantages that are inherent in this type of drive.

Frankly, my viewpoint is that of a "Doubting Thomas," for, having followed closely the operation of the Fifth Avenue Coach Co. and, in a general way, the whole subject of motorbus transportation, I cannot see that any authority up to this time has demonstrated satisfactorily in what manner this type of installation has proved satisfactory. In 1920, G. A. Green, then general manager and engineer of the Fifth Avenue Coach Co., presented before the Society a paper entitled Motorbus Transportation,[12] and enumerated the ideal conditions relating to motorcoach operation, but failed to mention the electric drive.

In 1922, in another paper on the Principles of Motorbus Design and Operation,[13] in setting forth the principles of motorbus design and operation, he again fails to mention the electric drive. In this article, specific attention is paid to an analysis of the different types of transmission that had been found satisfactory under varying conditions.

In 1923, W. P. Kennedy presented a paper on Trolley Buses and Flexible Vehicles for Street-Railway Service,[14] and went to great lengths to advocate various types of electric drive. In commenting on this paper,[15] R. E. Fielder, chief engineer of the Fifth Avenue Coach Co., stated:

> Regarding Mr. Kennedy's statement that the Fifth Avenue Coach Co. used 10 gasoline-electric motorbuses from 1908 to 1914 and would have continued the purchase of this type of equipment had it been available and in regular production, these chassis had mounted on them what were then our standard 34-passenger bodies and were later equipped with DeDion four-cylinder engines, of 110-mm. (4.33-in.) bore and 130-mm. (5.11-in.) stroke, each connected to a generator, this powerplant being mounted on a subframe. The power was conveyed through two motors connected by chains to each rear wheel. In first speed, the motors were connected in series; for second speed, in parallel. The acceleration of these buses was sluggish, it being necessary to race the engine to high speed to excite the generator so that enough current could be obtained for the motors to get the motorbus under way. The gasoline consumption was very much greater than that obtained with the standard mechanical-transmission motorbuses and, although the vehicle was similar, except for the electrical transmission, its unladen weight was 644 lb. greater than that of our then standard motorbus.
>
> Defects in the electrical units were often difficult to locate, even when experienced engineers were called in. Many useful bus-hours were consequently lost. Following the history of all the various electric transmissions in this Country and in Europe for the last 15 years, although substantial improvements have been made in them recently, mechanical transmissions also have improved and the difficulties formerly experienced with them have practically disappeared. I have no prejudice against either system and believe that the matter resolves itself into a question of which particular system will give the best practical results. In 1916, our experience and records caused us to standardize on a motorcoach equipped with the mechanical type of transmission that we now use. As we started at that time to build our own equipment, the matter of production was one that was within our own control and not a deciding factor in favor of mechanical-transmission motorcoach. Since 1916 we have tested other modern electric-transmissions. The result has again justified our decision.

Gasoline versus Electric Power

> Mr. Kennedy seems to admit that the electric system, particularly that of the trolley-bus, is not all that is needed, and that he looks to the gasoline bus to help him out. From my experience, I believe that sooner or later they will discard the electric end of it and accept the gasoline motorbus we are using today. I have visited a number of electric-transportation companies that are using trolley-buses in addition to the straight-gasoline motorbus, and have been advised that the later is by far the more efficient and economical to operate. As feeders, and for filling certain needs, I believe that the former type has its field. However, the trolley-car of today has its field, and it will be a long time before the motorbus entirely usurps it, if ever. It is significant that five of our customers, which are trolley-car companies, are giving us large repeat-orders. At least two of them have found that the cost of power for the motorbus is very much less than the cost of electricity for the trolley service. A company in New York State is finding that the motorbus is more economical to operate than the trolley-car.

In addition to this, we find in a paper[16] presented at the same occasion as Mr. Baldwin's, that C. O. Guernsey mentions the disadvantages of applying the gasoline-electric type of drive to rail-cars, as follows:

(1) The weight of the complete car is from 25 to 30 per cent higher

(2) The cost of a complete car is about 30 per cent higher

(3) The overall transmission-efficiency is much lower (70 to 75 per cent as compared to 90 per cent for normal conditions)

(4) Gasoline consumption is higher under average conditions

(5) Due to greater weight and lesser efficiency, higher horsepower is required

(6) Due to greater weight and lesser efficiency, speed is more seriously reduced on grades

(7) The maintenance of electrical equipment is not generally so well understood as is mechanical. The mechanical car contains nothing that is not common in principle to the automobile

These disadvantages, in my opinion, are also applicable to motorbus operation. Against the disadvantages enumerated up to this time, we have the outstanding claims that possibly have withstood the test of time, that is, (*a*) greater range of flexibility in final ratio and (*b*) smoother operation of the vehicle itself.

It seems to me that these factors, in the face of the apparent disadvantages, hardly warrant the widespread adoption of this type of drive, if economical operation is to be considered.

The motorbus industry and public-utility companies must as a whole be concerned with economical operation,

[12] See THE JOURNAL, July, 1920, p. 67.
[13] See THE JOURNAL, July, 1922, p. 13.
[14] See THE JOURNAL, September, 1923, p. 179.
[15] See THE JOURNAL, October, 1923, p. 324.
[16] See THE JOURNAL, July, 1925, p. 77.

if they properly sense their responsibility toward the general public, and should measure carefully every installation made in order that the final transportation costs may be as economical as possible.

It is noted in Mr. Baldwin's paper that in every instance, as near as can be detected, companies using his type of drive are public-utility companies. The psychology regarding this situation is to my mind a simple one. The electric-manufacturing interests see the trolley-car on the wane. They see public-utility companies picking up the motorbus as a practical means of offsetting the harm that is being done to them by individual operators. Public-utility companies are primarily and, for a long time, have been associated with the practical application of electricity.

The natural tendency of any of these organizations would be to adopt and put into use, as far as possible, units that bear the earmarks of partial electrical installation, for the reason that the men specifying and having under their control the operation of these vehicles have, in the majority of instances, electrical engineering training. These men see an opportunity not only to adopt the motorbus, but to carry out expensive engineering experiments, the cost of which, naturally, in an operation of this kind, must be borne by the general public. This appears to me to be short-sighted, before the majority of these concerns have demonstrated that they are capable of operating satisfactorily the types of motorcoach that have already been proved capable of operating economically on a 5-cent fare.

Mr. Baldwin states, and properly so, that public-utility companies are the proper ones to operate motorbuses. The reason for this is that it is assumed that they will use every endeavor to adopt this means of transportation as an economical medium in conjunction with the use of trolley-cars. I am inclined to believe that this assumption, in many cases, will not be correct.

It has already been demonstrated that many economies in the simple operation of trolley-cars themselves would have been adopted years ago if competition had been keen. It has also been amply demonstrated that public-utility companies, in many instances, even up to the present, are adverse to the use of this type of transportation.

A. W. S. Herrington, in a recent talk[17] before the Washington Section of the Society, stated:

> Many street-car companies are fighting the motorcoach by every means in their power;

also,

> Many persons have been deluding themselves into believing that the motorcoach is a good feeder to the outlying ends of their rail-transportation system, whereas, the economic place for the motorcoach is as a transportation medium in the congested areas feeding traffic out to points where the greater speed of the rail system begins to give it an advantage.

I remember that, at the convention of the American Electric Railway Association at Atlantic City last fall, various authorities showed no friendly feeling toward the motor vehicle as a profitable field. I remember distinctly that Ezra Whitman, of the Maryland Public Utilities Commission, stated that he had yet failed to see a motor-vehicle transportation operation turn in figures to that body that showed a profit; and he amplified his remarks by stating that the trackless-trolley operation in the City of Baltimore had failed to show a profit, because the cost of experimental engineering had been charged to operating expense. A further reflection of the attitude of some of the street-railway companies can be strengthened by some of the statements made on June 26, 1925, at Plattsburg, N. Y., by L. S. Storrs, a director in that industry. He is quoted as saying that

> The traction companies should put their house in order. . . . The electric-railway ideas must keep up with the times or they will pass out. . . . The selling of rides is a plain business proposition. . . . The merchant who deals in the best and cheapest rides is going to get the business.

I quote these authorities to amplify what I have said about the general psychology of the situation, regarding electric drives. In the face of repeated failures in both the passenger-car industry and the motorbus industry, these concerns apparently are strongly in favor of passing along to the general public the cost of what appears to be an experiment, which in time will not only react against the motorbus industry, but also against the electric-railway industry.

Independent operators have definitely proved that motorbuses can be operated economically. They have done this by cutting into the street-car business in the face of the adverse circumstances outlined above, and they have, generally speaking, followed the line of least resistance, that is, by adopting and using vehicles that had been turned out in quantities and could be purchased and operated economically because they were thoroughly understood by large service-organizations.

In direct contrast to this, we find that public-utility companies have not demonstrated that operation of motor vehicles by them will be a paying proposition; yet there is a tendency to adopt, in the face of history, a type of drive that up to this time has apparently been a complete failure.

The trackless-trolley is a type of vehicle that is simple as compared with the type under consideration; and we can expect in a more complicated arrangement of this kind that a great deal of expense will be entailed. It is safe to assume that if the trackless-trolley had to charge against operation in Baltimore a great deal of money for experimental engineering, such practice would overwhelm some of the public utilities that already are in dire straits because of the competition heretofore encountered by motorbuses that did not employ transmissions of this type.

As I see this type of drive from a practical standpoint, we are concerned with a greater number of units in the individual vehicle itself, greater complication, more weight, and high original cost.

The general complications of the vehicle itself will result in labor costs being higher for its up-keep, a greater number of lost hours, as pointed out by Mr. Fielder, and an additional line of automotive up-keep machinery with which some of the general repair-shops will not be fitted. The possibility and probability of having to carry a larger number of expensive units for replacement purposes, if the repair system is worked on the unit-repair basis, are also apparent.

Mr. Baldwin, in his charts, points out the general torque-characteristics and compares the electric drive with a four-cylinder engine. If what is needed in general motorbus operation is greater torque, why can this not be developed through the use of a larger gasoline engine, say one having six or eight cylinders? It is apparent to me that the additional cost of the original installation and up-keep of the vehicle itself for this type of engineering will not be so great as for the type of drive under consideration. Against this general line of argument regarding the necessity for greater torque

[17] See THE JOURNAL, August, 1925, p. 159.

we find that Mr. Green, in his comments on R. E. Plimpton's paper[18] entitled Fundamental Characteristics of Present-Day Buses in 1922, stated:

> Referring to Mr. Plimpton's remarks in regard to the possible future employment of six-cylinder motorbus engines and six-wheel coaches, our theory is to concentrate on the reduction rather than the addition of parts. As to the six-cylinder engine, for normal coach operation in the average American city, we believe that a four-cylinder engine of about 300-cu. in. capacity is adequate, assuming that proper design, speed and load variations can be taken care of by carbureter adjustments or gear-ratio modifications. If this assumption is correct, then certainly it is folly to add two more cylinders, thus increasing the first cost, weight, number of parts and fuel bills.

Of course, these remarks apply without regard to whether the engine is of the poppet or the sleeve-valve type. But it should be pointed out that the much desired silence and smoothness of operation are achieved comparatively easily with four-cylinder engines of the sleeve-valve type.

With regard to the six-wheel motorbus, here again are additional parts and, in all probability, additional weight and cost. In my judgment, the value of this construction has not been proved. In short, it would seem more logical to concentrate our energy on the improvement of the four-wheel system that has given and is giving an exceedingly good account of itself, than to expend any great amount of time and money on the development of a theory that, in my opinion, has not yet emerged from its early experimental stages.

Mr. Green not only argued for greater simplicity, but he brought out the question of weight. Mr. Baldwin states that the weight of the 64-passenger double-decked-body coach is 1724 lb. more than that of the standard Philadelphia Rapid Transit Co. chassis. This weight in itself does not appear to be serious, considering that the specifications of this chassis call for 36 x 6-in. tires on the front wheels and 36 x 6-in. dual rear-tires, which have a combined load-carrying capacity of 13,200 lb. It can be seen that any weight in addition to this amount naturally will place a premium upon tire costs. In the case of the electric drive, we are called upon to increase the weight on the tires by approximately 1 ton over that of the standard coach chassis, which according to specifications apparently carries an overload of 1836 lb. upon the tires when the vehicle is fully loaded, giving a total overload on the tires of 3560 lb. Such an overload must give short tire life with high costs, comparatively speaking.

In conclusion, I agree that the survival of the electric drive, like all other things, depends upon its fitness for the purpose intended; but I feel, also, that, in the face of the history concerning this type of drive, the statements of the public-utility men over a considerable period regarding their inability to survive on present revenues, and the impossibility of operating the coaches economically on a 5-cent fare, they should proceed with great caution with what appears to be an experimental unit and involves a great deal of complicated experimental-engineering work.

[18] See THE JOURNAL, August, 1922, p. 171.

MR. BALDWIN:—In closing, I wish to express my appreciation to those who have taken part in the discussion, which has been both interesting and helpful.

The only comment that I have to make is with regard to Mr. Winchester's contribution, which consists largely of quotations from various papers written from time to time on the subject of motorbuses. Had he been present at the meeting and heard the remarks of Mr. Green and others, I believe that answers would have been afforded to the doubts which are in his mind and are apparently based on their earlier published statements.

He quotes Mr. Fielder on the original electrically driven Fifth Avenue buses, which were designed and built under my direction, and were operated for 6 or 7 years by G. A. Green, who was then manager of the Fifth Avenue Coach Co., New York City. I was in touch with the operation of these motorbuses, and have recorded the facts in the paper under discussion.

Reference has been made to my statement that the gasoline-electric drive must prove itself in service. I am glad to say that the 215 electrically-driven motorbuses now being operated by the Philadelphia Rural Transit Co., in Philadelphia, have, in the last 9 months, run more than 4,000,000 miles. It is of interest to note that the company has recently placed an order for 135 additional electrically driven motorbuses.

Mr. Guernsey brought out a number of points in favor of the electric drive, which were included in my paper but were not read, owing to lack of time.

In closing the discussion, I wish to say that a number of prominent motorbus manufacturers and users, after an investigation of the subject by their own engineers, have placed large orders for electrically driven motorbus equipment.

When the gasoline-electric drive was first undertaken, the general impression was that it was especially adapted to use with motorbuses in city or suburban service, where frequent stops and a high operating-schedule are demanded. This has been shown to be true; the coaches in Philadelphia are operating on a schedule of between 11 and 12 m.p.h., with smoothness, freedom from jerks and safety.

Another characteristic of the electric drive, however, also fits it for interurban and even for passenger-car service, namely, the so-called "over-gear" that can be obtained, by which the driving-wheels operate at a higher speed with relation to that of the engine than do those with direct mechanical gear. This allows the engine to run more moderately, even at high vehicle-speeds.

The "over-gear" advantage appeals to the designer and manufacturer of passenger cars of all kinds; and it may be of interest to note that steps are being taken toward applying the electric drive to taxicab and passenger cars. These will embody starting and lighting, with the transmission feature. As time goes on, the field for the electric drive appears to become greater and more promising, and there is no reason that its use should not eventually become universal.

COMPANY AND NATIONAL STANDARDS

THE use of national standards within company organizations ordinarily involves some interpretation or condensation, and naturally a highly generalized standard meant to cover the needs of a whole range of industries, such as, a standard for bolts and nuts, for screw threads, or for shafting, cannot be completely adapted in this general form to the particular needs of a single company. It may call for too large a number of types and sizes, or it may not provide for some specially good or specially poor quality of product needed for a particular work. Therefore, the practice usually is to reproduce the national or trade association, or technical society, standard in some convenient and uniform style, perhaps in a loose-leaf handbook, or on charts to be tacked to the wall, in which all of the company's own practices with regard to the elimination of intermediate sizes and the like are crystallized. In Germany it has been the custom to use the national standard sheets very extensively, with a special mode of indication of regular stock sizes, sizes that can be furnished when specially called for, sizes that are never used, and the like directly imprinted upon the standard sheet as supplied by the national standardizing body. This has the advantage of saving considerable expense but is not well adapted to the form of publication that has been most common in the United States. It is particularly suited to loose-leaf single-page presentation of standards, which is the regular method in use on the Continent. For instance, the Germans, instead of having a pamphlet covering screw threads of all types and sizes, will have a large group of single sheets. The first sheet usually gives a general view or survey in convenient form of the whole field, showing the scheme of gradation of sizes, the different classes, if any, specific references to detailed sheets, and similar points. Another sheet may show Whitworth fine-thread, type 1, from 56 to 499-mm. (2.205 to 19.646-in.) diameter. Another may show single, trapezoidal thread from 10 to 300-mm. (0.3937 to 11.8110-in.) diameter, and so on. Thus, the sheets are split into convenient small units, suitable for the use, if necessary, of the individual mechanic or tool-setter who may be working on a single standard type of screw or machine element for a long period.

On the company standards committee, representation of the drafting and design, production, purchasing, stores, and sales departments, and shop superintendents or foremen and perhaps others will need to be provided for. If any one of these important groups is omitted from consideration in the standardization work, there may be large and unexpected resistance to the acceptance of the standard when it is ready, or important factors that had been neglected may be brought to light, when correction is difficult and expensive.

Every facility should be afforded the chief of the standards departmnet, and perhaps some members of his staff, to participate in national technical and trade association standardization work. The contact so made will be of inestimable value in bringing to the plant information about how other firms have met similar problems, and, furthermore, will keep the organization in close touch with new developments in industry that affect standards through changes in processes of manufacture and of assembly, new materials available for production and the like. As one man has put it, such contacts enable people to get in on the ground floor with reference to ideas that are still new and have important industrial reflexes.

Authority of Standards Department

An important decision that must be made in each firm is whether the standards work should be an adjunct of the designing department or be connected more directly to the higher management of the organization. The practice in Germany seems distinctly to favor the latter arrangement, and the standards departments there almost uniformly report to the general superintendent of the plant. The amount of authority that the standards department should have is again a matter of company policy. From the human point of view, it seems advantageous to put large authority in the departments that develop the standards under the general direction of the standards departments, keeping the standards bureau itself in a sort of advisory and correlating relationship. If the proper departments are represented on the various standards committees, there will be no difficulty in ensuring prompt realization of the work that is done. In one point, however, the practice seems common of requiring that use of special parts or materials not authorized by the standards shall be validated by some high administrative official, such as the chief of the standards department, an assistant to the general superintendent or the like. It is valuable, in cases where not too much inconvenience is involved, to route copies of all drawings for new designs through the standards department, in order that they may be effective as suggestions for new fields in which standards may be needed, or for modifications in old standards that may make them more widely adaptable or cheaper to manufacture.

Even very small savings on a single item, which are almost sure to be produced by the general process of cancelling out of duplications and adjustment of minor and non-essential differences that the standardization work calls for will be great in the aggregate and ordinarily sufficient to cover the cost of the standardization work many times over.

The Pratt & Whitney Co., to diminish the number of sizes carried in stock, has outlined a simple and effective expedient in some of its own work. The following table shows an excerpt from a possible list of screw sizes, given merely as an example:

	Diameter						
Length	¼	5/16	⅜	7/16	½	9/16	⅝
7/16	X		X		X		
½		X		X		X	
9/16	X		X		X		X
⅝		X		X		X	
11/16	X		X		X		X
¾		X		X		X	
13/16	X		X		X		X
⅞		X		X		X	
15/16	X		X		X		X
1		X		X		X	
1⅛	X		X		X		X

The list of standard length is written in the left-hand column, while the standard diameters are the headings of the columns. Instead of checking every standard length in a given range for every diameter, only every other length is checked, thus reducing the number of different combinations of diameter and length to one-half. Moreover, the lengths so checked are staggered in adjacent columns, which gives the opportunity of selecting the length required with a very small change in diameter, when the exact combination of length and diameter wanted does not appear on the list. Earle Buckingham, who furnished this illustration, points out that if, for example, a diameter of ½ in. is desired with a length of ⅞ in., the diameter can be changed to 7/16 or 9/16 in., whereas, if retaining the diameter is more important, a stock screw can be had by changing the length to 13/16 or 15/16 in. There are thus four alternatives, and few cases will arise where one of these will not serve practically as well as the size originally wanted.—From staff letter of American Engineering Standards Committee.

Analysis of Operating Costs of Automotive Equipment

By JOSEPH SCOTT[1]

LOS ANGELES GROUP PAPER *Illustrated with* CHARTS

ABSTRACT

ITEMS of the cost of operation of automotive equipment are classified as time and mileage costs, the former including the fixed charges and the latter the operating expenses. Mileage costs are divisible into two classes, one embracing charges directly dependent upon mileage and the other those having to do with actual operation but bearing no fixed relation to mileage, such as driver's wages, repairs due to accidents, body repairs, and the installation of miscellaneous equipment on the vehicles.

To determine the economic life of a unit automotive equipment by a graph, three curves are used, one representing obsolescence and interest on investment, another chassis repairs and the third the total cost, or a summation of the obsolescence and repair costs. These curves are plotted on the basis of cost with relation to both time and mileage. The obsolescence curve shows irregularities according to the mileage traveled in a definite period but drops gradually and constantly under uniform average-mileage operation. The repair curve rises almost constantly but less regularly. The point at which the two curves intersect indicates a mileage beyond which the equipment, if operated, will cost more to repair than before. The total cost increases each succeeding year and the excess of such cost above the first year's cost, after the obsolescence and repair curves cross, is the money that is lost by not replacing the equipment with new units.

Costs of obsolescence and of repairs both mount rapidly in the early part of the first year with low-mileage operation and then drop rapidly, but after the second year the total cost is fairly uniform and does not increase much from year to year, although it is constantly high. On the other hand, high-mileage operation results in much more economical use.

Total chassis-repair costs are shown to be much higher in the fourth year of operation than in the first, second, third and fifth years, but this does not prove that a unit can be used economically during the fourth and fifth years, as the cost for repairs after an overhaul will be from 20 to 40 per cent more than before the overhaul.

Repairs, obsolescence and running expenses, as for fuel, oil and tires, each amount to about one-third of the total of operation cost for a group of cars operated 942 miles per month for a period of 3 years, whereas, for a typical car operated only 477 miles per month for the same length of time the obsolescence amounted to more than one-half of the total cost, which indicates that not enough emphasis is placed upon the cost of obsolescence and interest on investment.

TWO factors have to be considered in a study of the cost of operation of a piece of automotive equipment. One is the time element, the other is the mileage element. The time element will include depreciation; interest on investment; insurance, whether carried by the operator or not; license fees; garage rental; and overhead, that is, administration. The mileage element will include gasoline, oil, tires, repairs, and drivers' wages.

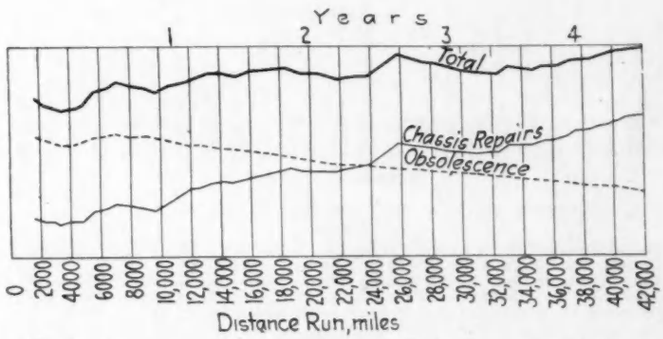


FIG. 1—CURVES FOR DETERMINING THE ECONOMIC LIFE OF AUTOMOTIVE EQUIPMENT

The Curves Show Obsolescence, or Depreciation, and Interest on Investment; Cost of Chassis Repairs; and Total Cost of Obsolescence and Repairs All Reduced to a Mileage and Time Basis. The Obsolescence Curve Drops Gradually with Average Uniform Operation and the Repairs Curve Rises Almost Constantly Until the Two Curves Cross. The Intersection Marks the Beginning of the End of the Economic Life of the Unit or the Type of Equipment and the Vehicles Should Be Watched Carefully When They Have Covered the Mileage Shown in the Figure below This Point

Depreciation or obsolescence, which term I prefer to use, is a continuous charge, whether the equipment is used or not, and interest on the investment is also a continuous charge. These two items are the only time-element charges that are caused and controlled directly by the cost of the piece of equipment. The other time-element charges, insurance, taxes, garage rental, and administration, are in no way controlled by the original cost of the unit.

The charges for gasoline, oil and tires that are to be laid directly to mileage are practically constant during the life of the equipment, the variation per mile probably being less than 1/3 cent, hence the cost of repairs is the only variable factor. Therefore, another division in the cost of operating a piece of equipment is introduced, namely, the cost of operation and the operating costs. An accident is chargeable to cost of operation but it is not an operating cost; neither are drivers' wages operating costs. Thus, when two pieces of equipment of the same rating or capacity are compared, only obsolescence, interest on the investment and chassis repairs should be compared. If a new piece of equipment is bought and is damaged badly in an accident during the first week of use, it surely would not be claimed that the cost of repairs for that piece of equipment or for that type of equipment should be charged to operating costs on a mileage basis. Objection has been made to ignoring, in the operating cost, the cost of repairs due to accidents because, when a piece of equipment needs repairing after an accident, work that is not directly concerned with the repair and replacement of the damaged parts is done in tearing down the mechanism, but, to balance this, unseen damage is done to the equipment that will appear in the costs later. Body repairs should

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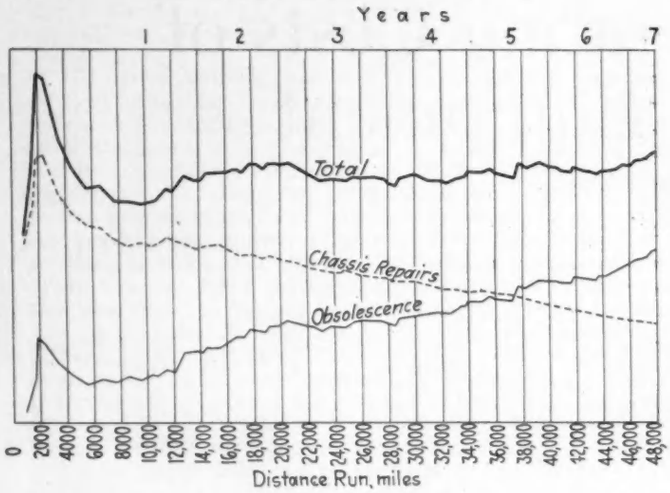

FIG. 2—EFFECT OF LOW MILEAGE DURING THE EARLY LIFE OF A TRUCK

Rapid Rise of the Curves during the First 2000 Miles of Operation Is the Result of Low Mileage and the Quick Drop in the Next 4000 Miles Is Due to Increased Operation. With 10,000 Miles of Operation by the End of the First Year, the Cumulative Cost Has Dropped to a Reasonable Figure. On a Basis of 48,000 Miles of Operation in 7 Years, the Variation in the Cost of Obsolescence and Repairs from the End of the First to the End of the Fifth Year Is Approximately 1 Cent per Mile, Whereas, under More Uniform Operation and Higher Mileage, as in Fig. 1, the Variation Is Approximately Only ½ Cent per Mile

not be included in the cost of operation, nor should miscellaneous installations, such as spot-lights, shock-absorbers, toolboxes, ladder irons or other small articles of equipment that probably are necessary in the service for which the equipment is to be used but that surely are not to be included in operating costs.

METHOD OF DETERMINING ECONOMIC LIFE

In making a study to determine the economic life of a piece of automotive equipment, the ideal operating-cost per mile that may be taken as a basis is a cost figure that is the same for the first day and the last day that the equipment is used. Repairs are an actual, absolute charge, and for that reason the obsolescence rate must be more or less arbitrary. It seems to be the general rule among dealers in automotive equipment to use, as obsolescence percentages, 35 per cent the first year, 20 per cent the second year, 15 per cent the third year, and 10 per cent each for the fourth and fifth years, with the assumption that, if the equipment is good enough to use at the end of 5 years, it will have 10 per cent of its original value left. This, of course, applies to equipment that is in continuous manufacture and sale and in which no radical change of model has been made.

For the foregoing reasons, when making a study by a graph, three curves are used, one representing chassis repairs, another obsolescence and interest on the investment and the third the total cost of these items. These curves are cumulative and show at any point the cost per mile from the date of purchase of the equipment. Reference is made to Fig. 1 to explain this method. It should be understood that the accompanying graphs, while correct, do not pertain to any one make of equipment and that no cost per mile is shown for any particular make or type of equipment.

It will be noticed that depreciation, or obsolescence, and interest, reduced to a mileage basis, produce a curve that is more or less regular according to the mileage run during any certain period, but, with uniform average mileage, the obsolescence and interest curve should drop gradually. The repairs curve rises almost constantly until it crosses the obsolescence curve. All equipment of the type to which such a chart applies should be watched closely when it has reached a mileage near this point and no extended repairs should be made on any such car or truck until a special curve is drawn for the particular piece of equipment, because, after this point is reached, repair costs will rise, the rate of increase being governed by the mileage it has run. It will be noticed, also, that the total cost for low-mileage equipment begins to rise after the first year of operation.

The amount of money represented by the excess of total cost above the cost for the first year, after the repairs and obsolescence curves cross, is the money lost by not selling the equipment or trading it in on the purchase of new equipment. A rate has been charged for the use of this equipment that includes the loss through obsolescence, so that money should be available in a sinking fund which, added to the allowance that would be made for the old equipment, would pay for the new. In the case of the particular piece of equipment represented by these curves, the total cost for the first 10,000 miles of operation was $555. For the second 10,000 miles, starting with and including the cost of overhaul, the cost was $756, which was $201 in excess of the cost for the first 10,000 miles. For the third 10,000 miles the cost was $925, an excess of $370 over the cost for the first 10,000 miles. These figures take no account of the 2 weeks' use of the car that was lost by reason of the overhaul.

EFFECTS OF LOW AND HIGH MILEAGES

Fig. 2 shows notably the effect of comparatively low mileage during the early life of a truck. The curves for obsolescence and interest and for chassis repairs both mount rapidly during the first 2000 miles of operation

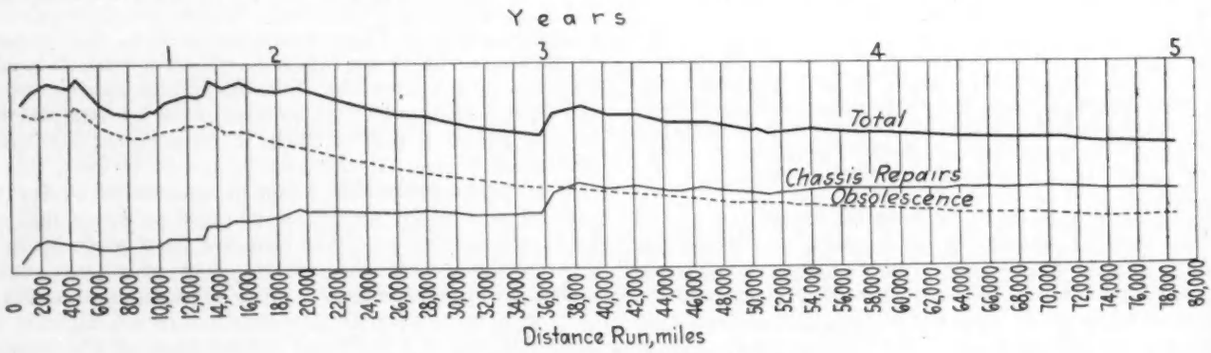

FIG. 3—EFFECT OF HIGH-MILEAGE OPERATION

Obsolescence and Repairs Curves for Equipment Operated About 79,000 Miles in 5 Years Cross at 37,000 Miles, Shortly After an Overhaul. High Mileage during the Succeeding 2 Years Resulted in Very Economical Use. Low Mileage in the First Half of the Second Year Caused a High Level of Total Cost for Obsolescence and Repairs. The Chart Shows Plainly the Economy of High-Mileage Operation

and then drop rapidly during the next 4000 miles. At the end of the year, at approximately 10,000 miles, the cumulative cost has dropped to a relatively reasonable figure. During the second year, the obsolescence, although it is at a lower average rate for the year than during the first year, is higher per mile in the first half of the year than it was during the last 2000 miles of operation in the preceding year. This also is caused by lower mileage during that period in the second year. From then on the mileage is fairly constant and the curve descends gradually. The variation in the cost of operation from the end of the first year to the end of the fifth year is approximately 1 cent per mile up to the time that the chassis-repair curve crosses the obsolescence curve, whereas, in Fig. 1, under more even mileage, the variation during that period is approximately ½ cent per mile.

Fig. 3 shows the effect of high mileage, 79,000 miles in 5 years. During the first 6 or 7 months of the second year, the mileage was not very high, and this is reflected in the rise of the obsolescence curve during this period. The obsolescence and repairs curves cross at about 37,000 miles, shortly after an overhaul, but the continued high mileage made during the following 2 years resulted in very economical operation. This indicates plainly the economy of high mileage, or, rather, the high cost of low

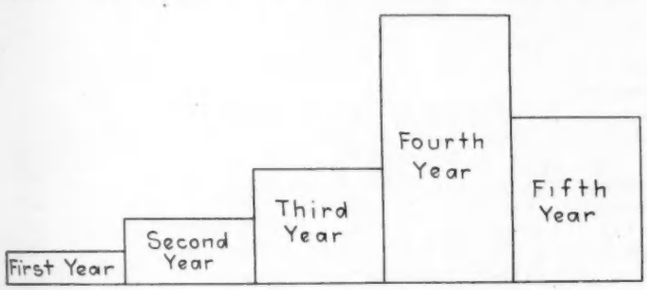

FIG. 4—CHASSIS-REPAIR COSTS FOR 5 YEARS
The Cost Is Much Greater in the Fourth Year than in Any of the Others, Which Seems To Indicate That It Would Be Economical To Retain and To Operate the Equipment during the Fourth and Fifth Years. This Should Not Be Done, However, Without Making a Special Study To Estimate Future Costs, Including Overhaul and Regular Repairs. Monthly Repair-Work Will Exceed by 20 to 40 Per Cent the Cost per Month of Such Work Prior to Overhaul

mileage, and is a strong argument in favor of either the pooling or the rental of equipment.

In support of this method of determining the economic life of automotive equipment, attention is invited to Fig. 4, which shows that in the first, second, third and fifth years of operation the total amount of money expended each year is much less than in the fourth year. This chart would seem to indicate that one could afford to operate the equipment to which the chart pertains during the fourth and fifth years. This should not be done, however, until a special study has been made and the future costs predicted, taking into account the cost of overhaul and regular repairs thereafter. The average monthly cost of repair-work will exceed by from 20 to 40 per cent the cost per month of such work prior to overhaul.

OBSOLESCENCE A MAJOR ITEM OF COST

Fig. 5 shows actual percentages of operating costs for a 3-year period for five automobiles of the same type used in practically the same service. The percentages are: oil 1.58, gasoline 17.38, tires 18.08, obsolescence and interest 30.45, and chassis repairs 32.52. The cost of tires amounts to approximately as much as the combined costs of gasoline and oil, and these three items together

FIG. 5—PERCENTAGES OF VARIOUS COSTS TO TOTAL
These Percentages Relate to Five Automobiles Operated an Average of 942 Miles per Month for 3 Years. Obsolescence and Chassis Repairs Each Account for Approximately One-Third of the Total Cost of Operation. Gasoline and Oil Cost About the Same as Tires, and the Three Items Together Amount to a Little More Than One-Third of the Total

make practically one-third of the total cost. Obsolescence and interest amount to practically one-third, and repairs to about one-third. These percentages are figured on an actual dollars-and-cents cost basis.

Fig. 6 shows actual percentages of operating costs for a 3-year period of an automobile operated a comparatively low mileage. The percentages are: oil 0.87, gaso-

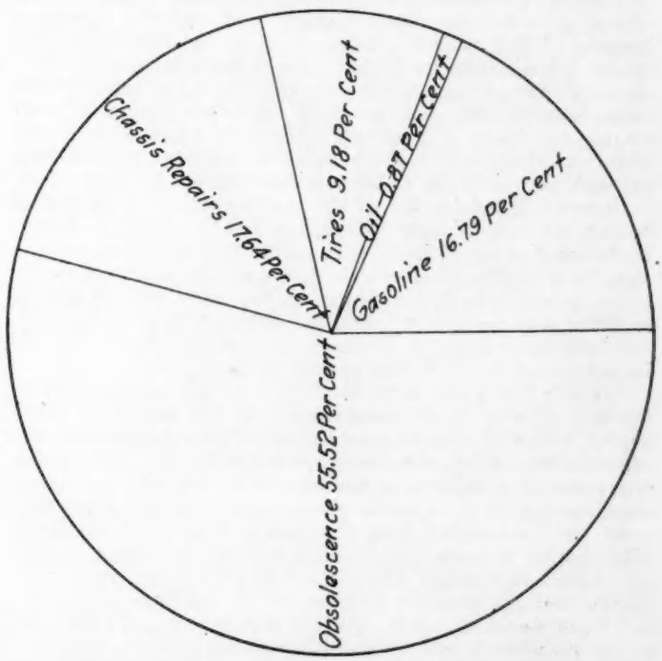

FIG. 6—EFFECT OF LOW MILEAGE ON COST PERCENTAGES
These Percentages Are Based on 3 Years' Operation of a Typical Automobile Operated an Average of 477 Miles per Month. Obsolescence Amounts to More Than One-Half of the Total Cost and This Appears to Prove That Not Enough Stress Is Placed upon the Cost of Depreciation and Interest on Investment

line 16.79, tires 9.18, chassis repairs 17.64, and obsolescence 55.52. Note particularly the high percentage of obsolescence and interest as compared with that of an average-mileage car as indicated in Fig. 5. This appears to prove that not enough stress is laid on the cost of obsolescence of automotive equipment.

These charts also show the effects of a number of special conditions, such as wrong use of the type of equipment, improperly placed equipment and excess equipment which is not used enough to justify owning it.

As for equipment that is not operated a large mileage, the kind of service rendered by it has an important bearing on the question whether or not an economical mileage-use of the car has been made. A truck used in line-construction work or in the installation of meters and services naturally will make a rather low mileage, as it is used primarily to carry men and materials to locations where the work is to be done, but its value for this purpose more than offsets the seemingly high cost per mile of operation. No fleet operator can afford to own equipment to take care of haulage peaks, however, and it is often cheaper to rent than to own equipment for such a purpose. For example, a company in Los Angeles had a haul once a week that averaged one 5-ton load. The rest of its loads could be handled by 2-ton and 3-ton trucks. It bought a 5-ton truck but should have rented a large truck for that one trip per week.

These charts, as stated, show the use of wrong types of equipment. If the repair cost per mile during a certain period is excessive, the equipment should not always be blamed but the conditions of use should be investigated. A truck that is built for use on smooth level roads probably would be a failure in the mountains because of its gear-ratio. A truck that pulls cable through conduits will show a low mileage and a high operating-cost unless a winch is installed on the truck. It costs less to operate the winch than to move the truck back and forth in the work. Operators of fleets are too prone to blame the equipment for their own errors of judgment in purchasing equipment or in methods of handling it.

SADI CARNOT

IN the year 1824, a minor Parisian publisher issued a short tract, entitled Reflexions sur la Puissance Motrice de Feu et sur les Machines Propres a Developper cette Puissance. The centenary of this, as it turned out, epoch-making event, was celebrated on Jan. 20, by a special meeting of the Societe des Ingenieurs Civils de France.

At the time that Carnot formulated his views, in this pamphlet the development of the steam engine had made evident to all the possibility of deriving work from heat. Heat was then commonly considered to be some sort of subtle fluid, known as caloric, as uncreatable and indestructible as matter itself. This hypothesis coordinated many well established facts of observation. Thus, the expansion of a body with rise of temperature was assumed to be due to an absorption of caloric. Specific heats were readily visualized, as representing merely the porosity of different materials, which were, in short, regarded as "heat sponges," of varying absorbent powers. Black explained latent heat on the hypothesis that water differed from ice in that it was a more porous "sponge," and could thus absorb a much larger quantity of caloric. The same materialistic concept about the real nature of heat formed the basis of Fourier's Theorie de Chaleur, in which heat was dealt with as if it were a material fluid flowing through porous media under specified heads.

Carnot's determination of the limiting efficiency of a heat engine, as now written in the familiar form $(T_1 - T_2)/T_1$ is the least of his titles to fame. Had he done no more than this, little justification could be found for Lord Kelvin's eulogium, in which he declared that, in the whole field of science he knew nothing greater than the work of Carnot. In fact, the formula in question is almost an obvious corollary to the hypothesis of the material nature of heat.

Carnot's two great achievements were the introduction of the idea of a cycle of operation and of the reversible heat-engine, which he showed must necessarily have the maximum efficiency consistent with the temperature limits. If we select any point of a cycle as a starting-place, the working agent must necessarily be in its original state, when it reaches this point on the completion of the cycle. This is, in fact, the definition of a cycle. Any other assumption would render all physics impossible, since it would involve as one consequence that the quantity of heat, or the old view of caloric, in 1 lb. of water at 0 deg. cent. (32 deg. fahr.) and at atmospheric pressure is not a constant quantity.

Even today thermodynamic theory affords little guidance to the designer of reciprocating engines. Moreover, when engineers ultimately became acquainted with the Carnot cycle, they not infrequently misunderstood it, and assumed Carnot to have maintained that the efficiency of any heat engine is proportional to $(T_1 - T_2)/T_1$. Experience showed that this is by no means the case with actual engines. Compounding, for example, was known to be highly advantageous, but the above formula affords no explanation of this. Carnot, however, did not say that the efficiency of any heat engine is represented by what in modern notation would be expressed by the above formula, but that the efficiency could not exceed the limit stated. Again he did not say that the efficiency of a heat engine is independent of the nature of the working agent, but that this would be the case were the engine reversible. It is, of course, now well recognized that the nature of the working agent is a very potent element in fixing the efficiency attainable with an actual heat-engine.

It was evident from Carnot's theorem that if heat were a form of energy it was not wholly convertible into mechanical work, and it was not unnatural to assume that logic required that the conversion should be all or none. It seemed just as reasonable to assume that no heat is lost in the driving of a steam engine as that no water is lost in the turning of a mill wheel. The idea of a distinction between high-grade and low-grade energy was of very slow growth. High-grade energy, such as the kinetic energy of a bullet, is wholly convertible into the low-grade energy of heat, but this low-grade form is only partially reconvertible into the high-grade type.

Kelvin was the first to establish the principle which is now expressed by the maxim that the entropy of the universe tends ever to increase. His deductions concerning the heat liberated and absorbed in the elastic deformation of metals have of late years afforded a delicate method of determining elastic-limits. Helmholtz applied Carnot's principles to calculate the voltage of a cell, given the heat due from the reactions occurring, and the rate of change of voltage with temperature.

There is today less faith in the all-sufficiency of energetics as an all-sufficing guide to physical research than was the case 25 years ago. The second law of thermodynamics is recognized as contingent only, markedly less absolute than the laws of the conservation of energy and the conservation of momentum. It is applicable only to large aggregates, to the macrocosm, not to the microcosm, and, as Tait pointed out years ago, is necessarily violated locally in any large mass of gas. Perrin has pointed out that an intelligent microbe, small enough to deal with the individual particles of the gamboge emulsions, would have no difficulty in evading this second law. The latter, in spite of its extraordinary importance, lacks the universality that has so far been found to attach to the other great generalizations mentioned above. —*Engineering* (London.)

Discussion of Papers at 1925 Automotive Transportation Meeting

THE discussion following the presentation of two of the papers at the Automotive Transportation Meeting of the Society which was held in Philadelphia last November is printed herewith. This discussion was almost entirely oral, although some written contributions were submitted. In accordance with the usual practice all discussion has been submitted to the various participants for their approval and to the authors for any additional comment that they cared to make. The corrected discussion, as received, is printed below.

Brief abstracts of the papers precede the discussion so that those of the members who did not read the papers when they were printed in the December, 1925, issue of THE JOURNAL can gather some knowledge of the subjects covered by reading the abstracts.

SIX-WHEEL MOTORCOACH OPERATION

BY W. F. EVANS[1]

ABSTRACT

THE six-wheel principle of chassis suspension represents a distinct advance in the art of construction of heavy-duty vehicles and has a tremendous future before it both for passenger and heavy-freight transportation, in the belief of officials of the Detroit Motorbus Co. after 1 year's operation of a fleet of six-wheel double-deck motorcoaches.

The company began operating dual-solid-tire double-deck motorcoaches 5½ years ago and after 2 years of operation arrived at the conviction that easier-riding vehicles must be provided to meet the desires of the public, to avoid damage to pavements and to decrease maintenance costs by reducing the vibration of the vehicles. Careful study of the progress made in the application of pneumatic tires to dual wheels on heavy-duty vehicles led to the conviction that their use on the double-deck motorcoaches was impractical. Attention was then diverted to developments in multi-wheel chassis, and the principle of weight distribution on more wheels, as in railroad practice, appealed to the officials as logical and as offering distinct advantages for motorcoaches. After serious investigation, an initial fleet of 37 six-wheel double-deck motorcoaches was placed in service in October and November, 1924. The total weight of one of these, with its crew and load of 60 passengers, is 22,000 lb. The vehicles were loaded at random several times, with a loadometer under each wheel, and the variation per wheel did not exceed 10 lb.

All of the advantages that were expected were realized fully in operation and many other advantages were gained. During the winter, when the streets of Detroit were glazed with ice for several days after a sleet storm, the motorcoaches showed no tendency to skid and always drew away from the curb without any spinning of the wheels. The motorcoaches have approximately 1 sq. in. of service-brake area for 17 lb. of vehicle weight as compared with 1 sq. in. to 34 lb. of weight in the dual-tire four-wheel motorcoaches. This large braking surface is to be increased nearly 50 per cent by the development of a propeller-shaft emergency brake. Because of the slight spring deflection under load, the floor of the motorcoaches rides practically level under all conditions of load, from empty to full. No spring breakages have occurred. The wheel-housing obstruction inside the vehicles is much less than in the dual-tire motorcoaches and it is planned to reduce this still more by widening the tread and using a heavy housing made integral with the chassis.

Lower maintenance and liability costs are outstanding results of the experience in operation of the vehicles. The only body work that has been necessary is renovating and repainting. Accidents have been greatly reduced because of the evenly balanced load and the non-skid characteristic of the chassis. Better running schedules have been maintained in all-season operation because of the more efficient traction and the better control of the vehicles.

[1] President, Detroit Motorbus Co., Detroit.

[2] Consulting engineer, Philadelphia.

THE DISCUSSION

WILLIAM P. PARKER[2]:—The paper is limited to the consideration of operation as affected by the six-wheel principle and the effect of that principle on the suspension and on the road; it does not discuss the question of drive. The Detroit Motorbus Co. operates 275 motorcoaches at the present time. It was compelled by force of circumstances to find a way out of certain difficulties and the paper presents the results of its trial of the 60 six-wheel coaches in conjunction with the operation of its other coaches and does not deal with any one type of vehicle, as the company operates several types. The company is still operating this fleet, to which it will shortly add 80 more six-wheel vehicles.

QUESTION:—How does the maintenance cost of six-wheel coaches compare with that of other coaches in Detroit?

MR. PARKER:—The indications are that they are cheaper. The six-wheel coaches have been in operation only 1 year and we have had the other coaches in operation 5½ years, but where we have been able to compare the six-wheel coach with the four-wheel type the comparison is entirely in favor of the former.

QUESTION:—How much of the ease of riding and reduced skidding of six-wheel vehicles is due to chassis construction and how much to pneumatic tires?

MR. PARKER:—That is problematical. Probably they both contribute to some extent, although I should say that the main contribution is by the six-wheel suspension.

QUESTION:—What is the acceleration of a six-wheel coach as compared with a Yellow coach or a Fifth Avenue coach?

MR. PARKER:—That is hardly a fair comparison because the six-wheel and the other coaches in the Detroit service have entirely different powerplants. The Fifth Avenue coach has a four-cylinder engine and the Yellow coach has a four-cylinder engine of about 55 hp., whereas the six-wheel coach has a six-cylinder engine of 75 hp.

QUESTION:—Is there any difference in tire wear on the rear axle?

MR. PARKER:—As Mr. Horton said wisely in his paper,[3] an operator does not make his decision upon one item of expense. Our opinion regarding pneumatic tires is that, while they cost more than solid tires, the total maintenance of the vehicle is less.

TIRE WEAR AND TIRE CHANGES

QUESTION:—How does the universal joint at the axle stand up?

BOYD V. EVANS[4]:—We have had some universal-joint trouble but it has been throughout the propeller-shaft and not confined to any one joint. That has been overcome with a new type of joint. The original joint was a new one with which we had had no experience on motorcoaches.

Regarding tires, we are getting an average of about 19,000 miles and find no difference in wear on the tires on the front axle and those on the rear axle. We are working into larger tires and balloon tires. Part of the new single-deck equipment that is coming through has balloon-tire equipment. That will give a comparison between balloon tires and high-pressure tires. We hope to get greatly increased mileage from the balloon tires.

B. J. LEMON[5]:—How long does it take to change a tire on the six-wheeler from the time the call comes in until the coach is on its way again?

MR. EVANS:—We have found that we can hardly leave the servicing of tires to the driver or the crew of the coach because it requires a little mechanical ability, so we have service trucks for the purpose, and if a motorbus is stopped by tire trouble the passengers are transferred to another one. When the service truck reaches the coach, about 5 minutes are required for the tire change.

MR. LEMON:—How long does it take the service truck to get there?

MR. EVANS:—The average time from the time the call comes in until the tire is changed is 18 min. We have service-truck stations at different points along the route.

LESS NOISE WITH PNEUMATIC TIRES

MR. LEMON:—Last year the company that I represent was interested in making some measurements of noises in passenger cars fitted with balloon tires versus high-pressure tires and, as an experiment, we used a 3-A audiometer, developed by the American Telephone & Telegraph Co., to measure the total noise in a representative unit of the various types of motorcoach in Detroit. This instrument produces a standard sound and measures outside sounds by masking them with the standard sound, which can be increased, the increase being indicated on a dial reading from zero to 100. Riding in the six-wheel coaches with this instrument, the registration on the dial, with the coaches running in second speed, was 35 and 41, respectively, on smooth asphalt and over street-railway crossings. In the coaches equipped with dual solid rear tires the noise in the single-deck type registered 56 and 61, respectively, and in the double-deck type it registered 50 and 60. For comparison with these readings, the noisiest place we could find around our plant was in either the blacksmith shop or the power-generating room, where the instrument registered about 75.

It seems to me that noise in motorcoaches is a rather interesting problem. We also tested street-cars, and it is surprising to know that they are not noisy inside when the windows are closed. The noise is on the outside and the trailer street-cars in Detroit registered not more than 35 points on the dial when running 15 m.p.h. with the windows closed.

H. L. ABBOTT:—Has Mr. Evans any figures on the relative stopping-ability of the six-wheel and four-wheel coach in slippery weather, as far as braking is concerned?

MR. EVANS:—I have no exact figures and can only say that we can almost stand a six-wheeler on its nose on a slippery street without evidence of skidding, whereas, with a vehicle of the same kind having dual wheels, and more particularly with solid tires, it would be almost suicidal to attempt to make the same stop.

LAWS WILL FORCE SIX-WHEEL CONSTRUCTION

A. W. S. HERRINGTON[6]:—Today I received a report from the Marine Corps after the first 10,000 miles of operation of a six-wheel truck between Quantico, Va., and Philadelphia Depot which makes the trip one way one day and returns the next day. The chief thing noted was the operators' report that the truck is much more satisfactory from the operator's standpoint than any vehicle the Marine Corps has ever had. It is very smooth-riding, it is easy to handle and, when operating on the hilly road between Philadelphia and Baltimore, it is possible to maintain a much higher rate of speed than with any solid-tired truck or any of the other trucks that are used in either the Marine Corps or the Army.

Certainly the tendency toward 20-in. wheels and 18-in. brake drums will not give us a brake that will give satisfactory service, particularly in motorcoach operation. Some of the discussion about dual-tire spacing has sounded to me like a good argument for the six-wheeler. I believe, however, that the six-wheel development will be confined to the larger sizes. There is no necessity for it, so far as I can see, in vehicles of 4 tons or less, but in the larger sizes I think we shall be forced into it by regulations that are going to be placed on the loads that may be carried upon single axles on motor vehicles. Mr. Horning recently made some interesting comments to me on the use of the six-wheeler in California, where there is an axle-load regulation that seems to make that type of vehicle desirable.

CHARLES FROESCH[7]:—Supplementing Major Herrington's comment on the size of brake drums, I think that, in view of the coming balloon tires, if we could adopt a different wheel standard, say 22-in. base diameter, we would get larger brake drums and better cooling.

SIX-WHEEL COACHES ON PNEUMATIC TIRES

CHESTER M. MCCREERY[8]:—I think that eventually nearly all six-wheel coaches will be on pneumatic tires. The cost per mile of the tires is a big factor that must be considered. However, you probably observed today, in going about the streets of Philadelphia, that streets which were smooth three or four months ago are rutty now. The cost of eliminating those ruts must be paid by somebody. The streets must be re-surfaced and, in the end, the cost comes out of the pocket of the rider,

[3] See THE JOURNAL, February, 1925, p. 592.

[4] M.S.A.E.—Chief engineer, Detroit Motorbus Co., Detroit.

[5] M.S.A.E.—Research department of the tire division, Morgan & Wright Tire Co., Detroit.

[6] M.S.A.E.—Chief engineer of the engineering and design section, motor transport division of the Quartermaster Corps, Camp Holabird, Md.

[7] M.S.A.E.—Engineer, International Motor Co., New York City.

[8] M.S.A.E.—Vice-president, Six Wheel Co., Philadelphia.

because he is the taxpayer. It seems to me that that is a fact which should fairly be considered as a part of the tire cost.

Another factor is the comfort of the passenger. One of the biggest problems that the motorcoach builder faces today is how to carry the large loads that the traction companies require in order to operate properly with a very low fare. It is very difficult to crowd passengers into a motorcoach and still make them comfortable. If we assume that motorcoaches will be mounted generally on pneumatic tires, and the tendency seems to be entirely in that direction, a practical means should be used for equipping pneumatic tires on the double-deck coaches.

The most important consideration of all in the use of pneumatic tires is that the motorcoach must appeal to the public if it is to survive, and to that end we must make the passenger comfortable. The maximum width of the motorcoach is limited by law and, to use dual-pneumatic tires, assuming that the equipment is 8-in. tires, it is necessary to consume inside the body line 8 in. for each of the two tires, with a space of approximately 2½ in. between the dual tires. Those 18½ in. come out of both sides of the body, which means the restriction of the seating capacity so that two seats on each side certainly are not up to the standard of comfort of the rest of the seats in the vehicle. This also has a tendency to reduce the width of the aisle.

OPERATING EXPERIENCE WITH GASOLINE-ELECTRIC MOTORCOACHES

BY R. HARLAN HORTON*

ABSTRACT

RESULTS obtained in 5-months' operation of a fleet of 130 gasoline-electric single-deck pneumatic-tire and double-deck dual-solid-tire motorcoaches by the Philadelphia Rural Transit Co. are described, and the author states that he knows of no other instance in which so large a fleet of motorcoaches has been placed in operation and given as dependable service with so little trouble. After this period of operation, the company finds more real enthusiasm and foresees more possibilities for the vehicles than at the outset and expects within a year to have operating data to show which will surpass any as yet presented.

Deliveries on the order for 200 of the new type coaches began in June, 1925, and by early November 130 had been placed in service. In this period the attention of the company has been concentrated upon the organization and equipment of garages, the training of about 250 men, the organization of a general shop-force, placing the vehicles in service, adjusting the service to the traffic and, in general, operating as an organization. No opportunity has been afforded to perfect the operation, to particularize and systematize carefully, to endeavor to realize maximum fuel-economy, and to determine the best maintenance program.

Outstanding advantages realized in the operation of this type of motorcoach are (*a*) rapid and smooth acceleration, which results in greater safety to passengers, reduction of claims for damages, faster running-time, reduction of labor costs, and a more attractive ride to sell to the public; (*b*) concentration of drivers' attention on the traffic, resulting in avoidance of collisions; (*c*) quiet operation, which reduces the number of complaints from residents along the routes; (*d*) decreased maintenance, which has made possible the cutting in half of the cost of regular maintenance, and (*e*) reduction of oil consumption.

The fundamental differences between the mechanical and the electrical equipment have affected greatly every phase of operation. The fact that the driver has no clutch and no gearshift lever to operate affects vitally the two most costly classes of operating expense, namely, labor costs and accident claims, hence the operating company can well afford the cost of additional fuel that may be necessary to carry the extra weight of the electrical apparatus. During October, 1925, the average schedule-speed maintained on the urban routes was 11.91 m.p.h., the maximum miles per gallon of gasoline for the double-deck motorcoach was 4.2, with 60 per cent of these vehicles operating 3.3 miles per gal. or more, and the single-deck motorcoaches showed the maximum of 7.5 miles per gal., with 80 per cent operating over 4.0 miles per gal. By comparison, six mechanical-drive motorcoaches of the same make and size operating at Buffalo averaged in October, 3.98 miles per gal., or 0.70 miles per gal. better than the Philadelphia company's expected minimum. Whereas gasoline costs about 4.5 cents per mile, the wage cost per mile is about 14.5 cents, hence a factor that affects fuel consumption 10 per cent affects operating costs about 0.45 cent, while a factor that affects speed affects the cost about 1.50 cents and also affects the fixed charges in the same ratio. Oil consumption in October averaged 1 qt. to 38 miles, as compared with 1 qt. per 24 miles by the six Buffalo mechanical-drive motorcoaches.

Reliability of the vehicle is of utmost importance, and the easier the maintenance is the more reliable the vehicle will be. At the start of operations the company adopted the customary program of inspecting the vehicles after every 2000 miles of operation but it is now studying the refinements that will be possible. A first step toward extending the period between inspections has been to establish inspections in one garage after each 4000 miles. The electric generators and motors need very little attention beyond oiling and greasing, and after 4000 miles plenty of lubricant remains in their bearings. The company is confident that the inspection intervals can be further increased, and intervals of 15,000 or even 25,000 miles do not appear to be an unreasonable expectation. It expects to change the entire principle of inspection and is working with manufacturers of electrical apparatus in the development of a watt-hour meter for attachment to the vehicles for measuring the power output or consumption, with a view to using the power consumption rather than mileage as a basis for determining when inspections are required. A brief description of the functioning of this instrument is given. Coordination of the reading of the instrument with office records of gasoline consumption of any individual vehicle will indicate positively when anything is wrong with the engine, the generator or the driver. In tests after overhauls, readings of the voltage and amperage will give an index of the functioning of the generator, and the watt-hour readings of a delicate meter installed for the purpose will show whether or not the motorcoach is in proper operating condition after an overhaul.

Major troubles that occurred in the early operation of the vehicles, such as overheating of the generators in excessively hot weather and with full passenger-loads from end to end of the routes, and means adopted to overcome them, are described. The usual amount of day-to-day minor troubles such as occur on any type

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of motorcoach has occurred and indicates only average performance, which, however, has been obtained without any special attempt at systematizing or perfecting the maintenance organization.

THE DISCUSSION

CHAIRMAN A. J. SCAIFE[10]:—Transportation is the greatest business in this Country, I think we will all concede. The branch in which we are interested, automotive transportation, was the third largest business in the Country in 1921. In 1923 it was the largest, according to a report of the Department of Commerce made public last Wednesday. The census of the industry is taken, I believe, every 2 years, and without question the automotive industry is holding its place in the year 1925. The commercial-vehicle branch of the industry was valued in 1921 at $40,000,000, and in 1923 it was valued at $300,000,000, showing that very rapid progress had been made in the 2 years. I believe that motorcoaches are included with commercial vehicles.

The papers at today's session deal in particular with the motorcoach in mass transportation in the larger cities, especially in Philadelphia and Detroit. To just what extent the gasoline-electric powerplant will fit into this transportation field is a question that we cannot answer today. Transportation of this kind is not entirely new. In fact, if I remember correctly, the gasoline-electric vehicle made its appearance about 1900 along with mechanically driven vehicles, and it has been coming up through the years, part of the time in and part of the time out of the picture. At present it seems to be very much to the front. I do not know whether or not the generator will be driven eventually by an oil-burning engine, a Diesel engine or a steam plant; there are possibilities all along that line. Several years ago, while in Philadelphia, I was talking with the operator of a large fleet of motor vehicles about some slight mechanical difficulty that I am free to acknowledge we still have, and he said,

> I do not understand why, in this day and generation, you should have any trouble with motor vehicles. They should be perfected by this time.

It looks to me, however, as though still greater things remain to be accomplished in this field. There are many things to do that have not been done, and it would be interesting to know what the future has in store for us in a transportation way. Whether the motorcoach will be driven mechanically or electrically time alone will tell.

MECHANICAL TRANSMISSION WILL BE IMPROVED

H. D. CHURCH[11]:—The flexibility, smoothness and silence of the electric drive undoubtedly will stimulate development of the conventional clutch and transmission for motorcoach work. The problem of rapid and silent gear-changing on motorcoaches is a difficult one, due to the high torques involved, as the inertia of the spinning train of gears, when shifting, is high. I have known instances in which the time required to make a clean shift was so great that the vehicle was decelerating before the next higher gear was engaged.

In my opinion, we have not reached the limit of development in clutches and transmissions. I believe that the near future will bring forth mechanisms that will give much smoother and more rapid acceleration, with quicker gear-shifting either up or down, together with less gear noise, than is usual today. At the same time, this result probably will be obtained with much less muscular effort on the part of the driver than is involved in present constructions.

It is to be hoped that in the development of the electric drive an effort will be made to decrease the weight and increase the over-all efficiency under maximum torque at minimum rear-wheel speeds.

Mr. Horton is inclined to criticize the differential gear. In my opinion, the conventional differential has been subjected to more criticism than is warranted. It has been my experience that a well-designed, properly lubricated differential of the conventional type is very free from any service troubles, and, while the satisfactory elimination of any gearing or mechanism that we can get along without is highly desirable, I feel that the differential of today is not a point of weakness in the best motorcoaches.

H. C. CROWELL:—Are there any developments in this Country along the line of steam-driven motorcoaches?

R. H. HORTON:—I do not know of any although I have heard rumors that some were to be started; in fact, I think Mr. Scaife mentioned such a plan this morning and I thought perhaps it would be a good idea and might mean the use of a cheaper fuel.

A. W. S. HERRINGTON:—What is your reaction to the possible use of pneumatic instead of solid tires in future motorcoaches?

MR. HORTON:—The question of pneumatic tires, as I see it, is wholly one of expense; that is, is the public willing to pay for them? I would not at present say that we would or would not want to adopt pneumatic tires. Without any doubt they ride more easily. There is also no question in my mind that they add to the expense materially. Our tire account shows that our tire expense for single-deck vehicles is very much greater than that for double-deck motorcoaches, but I am firmly of the opinion that the future will see pneumatic tires in general use.

A. H. LANGENHEIM:—Does the generator unit run at uniform speed, control being secured by resistance elements, as in trolley-cars?

MR. HORTON:—No, the generator is differentially wound and, as the speed of the engine increases, the output of the generator increases to supply more current to the motors, and the speed of the motorcoach is increased. The control is manipulated entirely by feeding more or less gasoline to the engine.

MR. LANGENHEIM:—Is it possible to depress the control pedal too fast and place a dangerous electrical load on the motors?

MR. HORTON:—No, the engine cannot be stalled, neither can it be accelerated too fast. The pedal can be pushed right down to the floor and the engine will pick-up at a uniform rate of speed.

J. C. MORRELL:—What is the average life of brake-lining on the single and double-deck gasoline-electric motorcoaches and how does this compare with similar straight gasoline motorcoach operation?

MR. HORTON:—We have not worn-out any yet. The greatest mileage we have accumulated on one coach is 15,750 miles. We have removed some brake-lining, but not because it was worn out. Some of our mechanically driven coaches have been run as high as 60,000 miles without a change of brake-lining. In our first fleet of 10 Yellow Coaches, the first change of brake-lining was made after 50,000 miles.

EFFICIENCY OF THE ELECTRIC DRIVE

J. H. GEISSE:—What is the actual electrical efficiency of the electric-drive coach?

[10] M.S.A.E.—Chief factory service engineer, White Motor Co., Cleveland.

[11] M.S.A.E.—Director of engineering, White Motor Co., Cleveland.

MR. HORTON:—I can merely quote what the designers have told us, which is that the electrical efficiency is, broadly, about 75 per cent and that, in ordinary position in high, it will be perhaps a little less than that of the mechanically driven coach, but certain advantages are obtained by using the most efficient sections of the engine curve, and further advantages are obtained because of the lower efficiency of the mechanical drive in the intermediate gears. A prominent designer was once asked what the efficiency was in intermediate gears and he said that he wished he knew.

B. J. LEMON:—What is your experience with tire equipment on the gasoline-electric motorcoaches?

MR. HORTON:—The answer to that would be about the same as for the brake-lining. We have had some trouble with the cushion tires on the double-deck motorcoaches, due to hitting ruts and raised rails on street-car tracks, which bent the steel rims and caused separation of the rubber from the base. As for actual wearing-out, I do not think we have changed any of them, and the mileage accumulated by the single-deck motorcoaches on pneumatic tires has given nothing very definite that I could tell about.

WALTER C. THEE:—What are the advantages of the six-cylinder engine for large motorcoaches?

MR. HORTON:—The chief advantage that I note is the quick response and more rapid acceleration obtained, which, to the operator, is one of the most important considerations.

O. P. LIEBREICH:—What is the relative acceleration of the gasoline-electric single-deck and double-deck motorcoaches?

MR. HORTON:—The tests I have made and which I call to mind showed an acceleration of about 2 miles per sec. per sec. up to 10 m.p.h. for the double-deck motorcoach. The rate for the single-deck vehicle is slightly greater than that.

MR. LIEBREICH:—What are the weights of the single-deck and double-deck gasoline-electric motorcoaches when empty?

MR. HORTON:—About 16,000 lb. for the single and slightly more than 17,000 lb. for the double-deck.

MR. LIEBREICH:—Do you believe six-cylinder or four-cylinder engines are preferable?

MR. HORTON:—The six-cylinder engine is decidedly preferable, I believe, because of its quicker response.

DETAILED OPERATING-DATA SOUGHT

A. E. HUTT[12]:—Last summer, at White Sulphur Springs, a paper on The Electric Drive for Gasoline-Propelled Motorcoaches[13] was presented by Henry S. Baldwin, of the General Electric Co., and in concluding his paper Mr. Baldwin stated that

> The survival of the electric drive depends, like all other things, upon its fitness for the purpose intended. To exist, it must demonstrate its superiority over the mechanical drive under service conditions.

Mr. Horton's company has now been operating vehicles of this type since last April, or for the last 6 months. It has about 200 in operation at present and has had about 100 for the last 4 months. I had looked forward to hearing this morning just what had been his company's experience with this drive during this period, backed by statistics showing the detailed cost of operation per vehicle-mile compared with similar vehicles with mechanical drive. The figures for the mechanical-drive vehicle can be obtained readily from any of the large motorcoach operating companies.

I believe that I speak for most of the members of the Society when I say that we are progressive and welcome anything new provided its superiority to the old can be proved by hard facts, which, with us, are figures. I therefore hope that as soon as they are available the Philadelphia Rural Transit Co. will give out the detailed cost figures of operation of its motorcoaches so that intelligent comparisons can be made.

Mr. Horton stated that the elimination of the gear-shift allows the driver to give all of his attention to the driving of the vehicle. This is undoubtedly true and is a great advantage, especially in city traffic. The gear type of transmission is anything but what engineers would employ if they had a suitable substitute. Many are giving their thought and time to designing and producing such a substitute. Possibly the solution has been found in the electric drive; on the other hand, the solution may come in the designing of an engine of such characteristics that we shall not need a variable-speed transmission. Who can predict what the ultimate automotive vehicle will be like, or even what it will be like 5 years from now?

I cannot see, however, how the absence of the differential will prevent skidding, which occurs almost entirely when braking. It seems to me that the presence of a positive connection at such time between the rear wheels and the engine is an asset rather than otherwise. Braking with the gasoline-electric drive is the same as braking with the mechanical drive with the clutch disengaged, which is admitted by anyone familiar with driving a motor vehicle to be a dangerous practice on a wet pavement.

Mr. Horton said that his company has now reached a point where it has decided to establish a 4000-mile inspection period instead of a 2000-mile period and that this is a step toward an even greater mileage-period. This certainly is progress, but in view of the fact that his company has not yet been able to obtain any definite figures on its operation, this step seems to me rather risky. The fact should not be overlooked that the purpose of periodical inspections is to forestall delays due to mechanical troubles while the vehicle is in service, as such delays, in addition to causing inconvenience to passengers and reflecting upon the quality of the service, are very costly. One hour's delay on the road, especially in peak-load periods, costs as much as 15 or 20 hr. of a mechanic's time in the garage.

With the gasoline-electric drive, Mr. Horton remarked, rear-axle trouble will be confined to a worm and wheel instead of extending to the complicated differential. I think he should have said two worms and two wheels, whereas in the mechanical-drive rear-axle there is but one worm and one wheel. As regards the complicated differential, which, by the way, is a compact arrangement of two spur gears and two or four satellite gears, all running in oil, in all of my experience with the worm-drive axle, covering several million miles, I have yet to see the first failure of a differential.

Mr. Horton also observed that economy of motor-driven vehicles is too often cited in terms of gasoline consumption. This certainly was the case formerly so far as motorcoaches were concerned but is not so today, as most manufacturers admit that it is the total cost of operation which must be considered, regardless of individual items of expense. If the gasoline-electric motorcoach can demonstrate its ability to maintain a higher schedule-speed over all kinds of route, including grades,

[12] M.S.A.E.—President, Westchester County Bus System, Inc., New York City.

[13] See THE JOURNAL, July, 1925, p. 95.

than the mechanical-drive coach, it will automatically have demonstrated its right to burn more fuel, as it can offset considerable added expense for fuel by economy in platform help.

The gasoline-electric motorcoach is considerably heavier and more costly than the mechanical-drive vehicle and it is only logical that operators should expect to obtain sufficient added advantage to compensate for this extra weight and money. Anything that is good will win recognition eventually by virtue of its worth, which will make itself manifest in time, but it will receive quicker acceptance if those who are first to use it are willing to enlighten the rest of the world regarding their experience with it. Several other companies besides the Philadelphia Rural Transit Co. are trying out this new drive, so let us hope that either that organization or one of the other companies will supply the Society with operating statistics in the near future, so that the industry as a whole may benefit and the electric drive, if deserving of it, will receive general acceptance as soon as possible.

Tests with Single-Motor-Drive Coach

CHARLES FROESCH[14]:—While the experience with this type of drive by the company with which I am connected is somewhat limited, the results of our experiments, so far, fully agree with Mr. Horton's experience with gasoline-electric-drive motorcoaches. It would seem, however, that greater advantages can be gained with a single-deck one-man-operated vehicle, because the driver must not only open and close the door but must collect the fares as well, and when he also has to shift gears double time is lost, therefore the ease of control is a very important factor in one-man-coach operation.

The International Motor Co. has developed, in conjunction with the General Electric Co., a single-motor-drive motorcoach chassis of 25 or 29 passenger-seat capacity which has been put through a series of tests recently to obtain comparative performance data between the mechanical transmission and the electric drive. We have found that for interurban work no gain in schedule speed with electric drive resulted and that the fuel consumption was not quite so low as with the mechanical transmission. The figures are 7¼ and 8 miles per gal. respectively. The hill-climbing ability of the gasoline-electric chassis is inferior under light-load conditions but when overloaded it pulls considerably more but at a slightly lower speed than the mechanical-drive chassis. This probably is due to the fact that the engine speed is not proportional to the vehicle speed, which makes it possible to adjust the generator-field resistances for the most efficient engine-speed. In the course of a day's work the gasoline-electric drive has the advantage in acceleration. Our tests indicate that, with the electric drive, we are just able to follow the speed-time curve of our mechanical-drive motorcoach up to 18 m.p.h.; after that, the latter has the advantage, but this curve was obtained under driving conditions that could not endure for any length of time.

A check made in several large cities where many single-deck motorcoaches are in daily operation shows that an average time-loss of 5 to 7 sec. occurs from standing still to a free running-speed of 25 m.p.h. This loss averages from 1½ to almost 2 sec. during shifts, and during this time momentum is lost, especially when climbing grades. It is this loss that the electric drive eliminates. Furthermore, control by the throttle alone assures constant and easily duplicated performance. This, however, does not mean the same constant fuel-economy. In our tests two different drivers, covering the same distance on the same course and in the same time, showed a difference of 0.9 mile per gal.

The starting lag, which is common with all gasoline-electric drives, has been decreased to the minimum by eliminating the exciter, which, incidentally, absorbs about 1⅛ hp. at 1500 r.p.m. Excitation is direct from the battery through a teaser field on the generator. The current drawn is, I believe, 1¼ amp-hr. To prevent overloading the engine on the grades, a current relay that cuts-in at 180 amp. is used, thus really providing a two-speed shift for the engine. The generator has a rating of 125 volts and 200 amp. at 1200 r.p.m. and the motor rating is 125 volts and 140 amp. at 900 r.p.m. The total weight of the drive, including controller, wiring and brake-resistance grids, is 1525 lb. The use of larger electrical units than was contemplated at first has permitted a great reduction in working temperature, not only in the electrical units but in the cooling system as well, and this, of course, has reduced all losses to the minimum.

The advantage of a single-motor drive is that it can be fitted in a standard chassis without major changes. This is important when mixed fleets are used for urban and interurban transportation. The interchangeability of parts is also an advantage in manufacture and service. The adaptation of this type of drive to motorcoaches and the demand for it is an acknowledgment that the engineer has failed to produce a mechanism that can accomplish the same results mechanically as can be produced hydraulically or electrically. However, the gasoline-electric drive is not all that it should be. It adds from 1100 to 1700 lb. of weight to the chassis and costs about $1,000 to $1,300 more than the mechanical drive. Its quietness still leaves much to be desired so far as generator and motor brushes are concerned. I understand, however, that the solution of this troublesome problem is at hand. Its over-all efficiency is inferior to that of the gearbox, but this efficiency is more than compensated for by the increased schedule speed over routes having more than five stops per mile.

I advocate a more liberal use of automotive materials in the building of the gasoline-electric drive, whose units appear more like street-car units than parts for automotive transmissions. An ultimate solution may be a combination drive, that is, one using the generator and electric motor during the acceleration periods and having some sort of mechanical connection between the two to provide a positive drive that will eliminate the high-speed loss in efficiency when the generator and motor speeds reach a relative balance. This would permit the use of smaller units and provide intermittent cooling, which would be a decided advantage for motorcoach work.

Trolley-car operators are inclined to look upon the single-motor gasoline-electric drive with suspicion, and mention the fact that all of their cars are equipped with two motors. They point out that in case of a burn-out they still have the other motor to run the car to the barn. But why draw a comparison between the trolley-car and the motorcoach that produces its own electricity? When the engine or the generator goes wrong, the drive ceases to function. The installation of two motors on a single-deck motorcoach chassis seems like an acknowledgment of the unreliability of the single motor, but a single motor can be operated with the same degree of reliability as two motors by making it of adequate size.

[14] M.S.A.E.—Engineer, International Motor Co., Long Island City, N. Y.

Efficiency Tests of Mechanical Drive

C. O. Guernsey[15]:—The question of efficiency of the mechanical transmission has been raised. Unfortunately, I have not the figures with me, but some years ago a series of tests that were nearly as accurate as possible was made to determine the efficiency. These tests covered over-all efficiency of the usual four-speed gearbox and the final drive and were made by testing the engine actually in the chassis with a prony brake and, later, driving with the same engine through the same speed range and taking the power from the rear axle on another prony brake. Leaving out of account the varying efficiency of the final drive, we were much surprised to find that we obtained as high efficiency on some of the lower gears as on direct drive. Five axles were tested, as I recall. The efficiency of the worm-gear varied considerably with the speed at which it was operated and therefore the over-all efficiency of the transmission and axle with the worm-gear was considerably lower on the lower gears than it was on direct drive because of the fact that the worm-gear itself had a lower efficiency due to its lesser speed. However, taking an axle having bevel and spur-gear reduction, of either the double reduction or internal-gear type, in which the efficiency of the axle itself was fairly constant, we found that the efficiency on the lower gears was so near to that on the higher gears that the difference was negligible. The only way in which I can account for this is that the rate of rotation of the gears in the lubricant was less and consequently there was less loss in efficiency. We had an over-all efficiency of 96 per cent when running with the spur-gear axle.

The question of gasoline consumption with the electric drive has been raised. I do not think we should pay too much attention to the efficiency of the electric drive, because it makes possible so many savings in the power-plant.

I should like to see comparative data from similar operating conditions, as mentioned by Mr. Froesch. I would be particularly interested also in learning the effect of pneumatic tires on double-deck-coach operation, that is, the maintenance cost per mile of the pneumatic tire under given conditions, and the maintenance cost of the chassis and body under given conditions, as compared with similar data for solid tires under the same conditions.

M. C. Horine[16]:—As I understand it, the advantage of the gasoline-electric drive is chiefly the ease of control and more rapid acceleration due to elimination of the step-by-step change in gear-reduction. Those advantages are not necessarily exclusive to the electric drive. Is there not some possibility of accomplishing the same results with a conventional gear-drive by using some means of mechanical gearshift control? The Society has had a number of these devices explained and demonstrated. Some of them are in use on light vehicles. If they will work on light vehicles, why, with further development, will they not work on heavy vehicles, and, if they will do so, can we not approximate with the more efficient, lighter, simpler, and cheaper mechanical drive, the results that are obtained with the electric drive? This is not propounded as a question but is merely offered as a suggestion.

[15] M.S.A.E.—Chief engineer, automotive car division, J. G. Brill Co., Philadelphia.

[16] M.S.A.E.—Sales promotion engineer, International Motor Co., New York City.

MOTOR VEHICLES IN 1965

FORECASTS of highway traffic in New York City, as set forth in the Transit and Transportation Problem just issued by the Regional Plan of New York City and Its Environs, are highly amusing. These are based primarily upon the assumption of a continued growth in motor-vehicle registration for the New York City region, at a yearly rate of increase approximating that for the last 3 or 4 years, to 1965. Registration then is predicted at 6,700,000 motor vehicles for the New York City region, nearly six times the present registration, with about twice the population, reflecting a motor-vehicle density in 1965 three times that in effect at present. In 1935 registration is predicted at 3,150,000, nearly three times present returns, against a population increase of but 25 per cent, reflecting a density two and a quarter times that now in effect. The New York City region now returns 8.5 persons per motor vehicle registered, against 5.8 persons for continental United States. Regional Plan forecasts reflect, for the New York City region, 3.8 persons per registered motor-vehicle in 1935 and 3.1 in 1965.

Now for the inevitable comparison; the scale against which to check these forecasts. The average motor-car builder expects the ultimate density throughout the United States to return at least one motor-vehicle per family. This condition is reflected substantially in 1935 by a curve of probable growth in motor-vehicle registration developed from observations through 1924 by Prof. Lowell J. Reed, of the Johns Hopkins University and published in a recent issue of the *Journal of the American Statistical Association*. While we may not place too much dependence upon this theoretical method of forecasting and, while year by year predictions by this method are of little or no value, over a period of years, to and beyond normal saturation, some results by this method carry reasonable conviction. In the present instance the Reed plot closely approximates the one car per family goal set by manufacturers. These forecasts for continental United States place 1935 registration at 28,000,000, reflecting 4.7 persons per registered motor-vehicle and 1965 at 35,000,000 or 4.6 persons per motor vehicle, the population for respective years being the forecast by Prof. Raymond Pearl, of the Johns Hopkins University.

New York City region motor-vehicle registration is now 5.8 per cent of that for continental United States. Forecasts by the Regional Plan of New York City place this percentage at 11.3 in 1935 and at 19.2 in 1965, forecasting a rate of growth in motor vehicles for the region about three times that anticipated for the United States. It should also be noted that, in the Middle Atlantic States where the habit-condition index of population is high, indicating prosperity and purchasing power well above the average for the country, the motor-vehicle density index is low, due entirely to the high population density of New York City, which conditions are likely to continue.

The method of forecasting motor-vehicle registration employed by the Regional Plan of New York City is as sensible and gives results about as reasonable as would be obtained by plotting the growth of a youth from age 10 to 16, and forecasting therefrom pasture requirements 40 years hence, for sheep to supply wool for garments to clothe beings 30 ft. tall. Only the period of maximum growth has been considered. The inevitable tapering-off to impending maturity or saturation has been neglected. Resulting determinations are several times too high. In another setting these glaring errors might occasion but amused comment; presented within a quasi-public document, and attached to a notable personnel the matter takes on a more serious aspect.—G. R. Wadsworth in *The Sun* (New York).

LOGIC APPLIED TO FAILURES

IT might be laid down that, short of abuse, main units of motor vehicles should be capable of giving 300,000 miles' useful life, if they are given reasonable maintenance. At the same time it might be decided that the machine as a whole, subject to good maintenance all the time, should be capable of running the minimum of 40,000 miles without the necessity for opening up the main units or receiving a general overhaul. The fixing of these two figures has a large bearing on the general policy adopted in developing the design. A number of parts in any mechanism are designed simply and solely from the point of view of wear as distinct from that of stress, and clearly all such parts are very directly affected by the values placed on the two figures defined. A further result also follows from the above, that if the design has been successfully carried through, the machine under normal working conditions will have the properties of the wonderful "one-horse shay," in that all its wearing parts will require attention at the end of 40,000 miles, and the whole thing will fall to pieces at the end of 300,000 miles. There is no point in having a rear axle that will run 60,000 miles between overhauls if the rest of the machine needs to come down at 40,000 miles. Either the axle is too good and expensive for the class of vehicle concerned, or the rest of the units are not good enough. No change in existing methods is justified unless it exhibits definite advantages when considered from the point of view of the object to be achieved by the design. Such an outlook is by no means too conservative and should never lead to stagnation. It merely assures evolution rather than revolution. Simplicity in the means of attaining a given object is invariably better engineering and often actually more technically perfect than complication.

No diagnosis of trouble can be accurate which has not been based on the very widest possible knowledge of the conditions under which any given failure occurred. A certain looseness in dealing with this point is too often apparent and unavoidably results sooner or later in an incorrect appreciation of the facts that have been causing unsatisfactory service, with consequent evil effect on the sum total of the experience of the organization concerned and on new designs put out by it. It is a common occurrence, when one or two failures of apparently similar nature have occurred, for any further failures to be ascribed to a common cause. Nothing could be worse in the case of an investigator who is to do any good in the direction of preventing further recurrences.

Take the simple case of a burnt valve. Admittedly, most of such instances can be attributed to one or two causes, but the complete list of possibilities is surprisingly long.

(1) No clearance between valve and tappet
(2) Unsuitable material
(3) Wrongly timed magneto
(4) Wrongly tuned carbureter
(5) Insufficient clearance between stem and guide
(6) Stem gummed-up
(7) Defective water-circulation
(8) Valve-spring too weak
(9) Valve-spring broken or ineffective
(10) Exhaust passages restricted
(11) Dirty engine
(12) Distortion of valve or seat

It is practically impossible when drafting a specification for material to cover all eventualities, and in any case it would hardly be desirable from a commercial point of view. It follows, therefore, that a failure may result even in the case of material conforming to all the specified tests. For this reason the interpretation of test results and the decision as to whether the material is at fault are matters requiring considerable experience and knowledge of the subject, rendered all the more necessary by the lack of cut-and-dried standards by which to judge. To a very great extent the investigation of failures from the point of view of design may be said to be compounded of experience, knowledge of the facts and the right mental attitude. The stiffness of a part or series of parts, using the word in its engineering sense of resistance to deflection under tensile, compressive, torsional, or bending stresses, as the case may be, is a quality often left unconsidered, except in cases in which it is very obviously of importance. The presence, in a chain of members transmitting a force to the point where it is met by its reaction, of members of widely varying specific stiffnesses may, however, be of vital moment. For example, a torsionally ultra-stiff axle-shaft is capable of causing the failure of a differential, if other circumstances permit. A stiff frame, subjected to a given shock-load, may fail, whereas a more flexible one, subjected to the same load, would stand indefinitely.

Generally speaking, the use in cases where stresses can be calculated of carefully considered factors of safety, coupled with a logical use of empirical formulas and methods of comparison with preceding practice, will avoid bad mistakes. The latter method, used with discretion and within limits, forms a very valuable means of ensuring continuity in policy and of applying the results of previous practice to the numerous details in automobile design where exact calculation is impossible.—From a paper presented by J. D. Parkes at a meeting of the Institution of Automobile Engineers and published in *Automobile Engineer*.

HIGHWAY RESEARCH

A CENSUS of major highway-research activities in the United States has been made by the Highway Research Board and is published by the Bureau of Public Roads. It deserves very careful attention. Some 90 separate investigations are being made in economics, operation, design, design of vehicles, and construction. A number of these studies also have two or more distinct phases which involve virtually separate investigations so that it may fairly be said that over 100 major tasks in highway research are being carried out by public roads departments, technical schools and engineering and industrial organizations. Numerically this is an excellent record. The greater significance is, however, in the character of the investigations. None of them are routine tests or the incidental developments of general truths from routine tests. They are definite undertakings in research study. Most of them relate to details of materials, methods and equipment used in construction, but others, a considerable number, are directed toward the determination of broad truths of experience and the fundamental principles of highway design and operation. Not the least important fact to be noted is the cognizance being taken, in a round half-dozen studies being made of the design of vehicles, of the important relation that exists between the vehicle and the road—their reactions upon each other. Outstanding here and in a score of other studies is the growing realization of road engineers that highway development is as fully a problem of operation as it is a problem of construction.—*Engineering News-Record.*

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Motorcoach Builder's Attitude Toward Changes in Standard Designs

By E. W. Templin[1]

Automotive Transportation Meeting Paper *Illustrated with* Drawing

ABSTRACT

Operators of motorcoaches make many requests for changes in the builders' standard designs or for special equipment without giving sufficient consideration to how these changes will affect the vehicle as a whole, the cost of making them and the result with respect to deliveries and future service by the builder. A large number of these requests are for trivial changes that may improve the operation of the vehicle or its serviceability to the passengers very little if at all. A number of comments on this subject by representative men in the motorcoach-building industry are given and indicate that, while some changes demanded by operators have proved desirable and have been incorporated in the standard designs, the making of changes is regarded as objectionable in general and operates to the disadvantage of both the builder and operator. Some of the objections are that changes add to the manufacturing cost and to the stock of necessary service parts, require special tool-equipment, delay deliveries of vehicles, and make servicing more difficult. Most requests for changes now come from new operators; experienced operators are beginning to realize that the aim of the builder is to provide the best possible motorcoach and are willing to accept the result of his experience and experiments, hence requests for changes were less frequent in the first half of 1925 than formerly.

Fundamental requirements that the motorcoach should meet are specified as (*a*) safety, (*b*) comfort, (*c*) economy, and (*d*) performance, and under these the author itemizes the factors that affect each. He then discusses in sequence what each factor must accomplish to satisfy the operator and avoid requests for changes.

To illustrate what the making of an apparently minor change from standard design entails, an example is given of the effect of a request that the floor obstruction caused by the rear-wheel housings be reduced, which would necessitate the designing and testing of a new frame at a total cost of $1,000 to $2,000 for the first sample frame, $2,000 to $3,000 for an extended test and $4,900 for special production-tools; and the designing and experimental work on special axles at a cost of $1,000, special patterns and tools at a cost of about $500, and changes in frame brackets, brake rigging and gas-tank supports at a cost of $45. Therefore, to make this small improvement to the comfort of passengers would entail an extra cost of $313 for each of a lot of 50 coaches, added to which would be the inconvenience to the builder, delay in delivery, and probable future difficulty and delay in securing duplicate vehicles. Somebody must pay for all this work. The operator is reluctant to do so, as the cost appears unreasonable, but eventually the builder must get cost and a profit if he is to remain in business and supply additional vehicles and service parts.

Whether or not an alteration in design or a change in any element is worthwhile depends upon its relative importance and how the gain in one factor will affect other factors. This can be evaluated by preparing a list of all the main factors, assigning a total value to the whole list and a fractional value to each item, then altering the values of other items affected by the contemplated change, and noting the gain or loss in the whole value. An example of such a chart and how the system is used is given. In conclusion, the author asks operators to forbear from asking for design changes or for special features until these can be given seasoned consideration and a thorough test so that, if proved worthwhile, they can become standardized improvements in due time with the minimum cost for development.

An operator who has determined upon a type of motorcoach that most nearly meets the requirements of his operating conditions often asks the builder to agree to make certain alterations in or additions to the vehicle before he can fully agree to sign the sales contract. A list of such requests has been gleaned from the files of our company in the last few months. Let us consider, without losing sight of the whole picture, how important and valuable some of these changes are. These requests for changes related to the following items:

CHASSIS

Type of head-lamps	Size of generator
Make of head-lamps	Generator mounting
Design of clutch	Generator regulator
Sizes of pilot bearing	Radiator cap
Make of magneto	Make of carbureter
Compressor coupling	Location of battery

Make of lubricating system

BODY

Location of signal button	Addition of gascolator
Location of steering column	Piping and valve for door mechanism and brake system
Make of speedometer	
Location of heater valve	
Length of hood to suit body design	Type of window sash
	Location of marker and dash-lights
Size of engine	
Special gas tank	Special colors
Shape of pedals	Special seating arrangement
Design of hand lever	Special destination signs
Special powerplant	Special seats
Design of trunnion pin	Special door-opening device

Changes Requested Have Boomerang Qualities

The ideas upon this subject of a few representative men in the motorcoach-building industry will be of interest. A supervisor of service writes that

> Changes made in established standard models to suit the particular specifications of an operator add to the inventory of service stock, often require special tool-equipment to give proper service, involve a complete revision of parts-lists, and increase the liability to errors in furnishing spare parts. One such change, which at the time was not considered radical, affected 40 individual items. In a large majority of cases

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the changes requested by operators, and considered by them of minor importance, showed, when analyzed, that they would entail a large increase in service parts without any increase in operating efficiency. If operators realized the boomerang qualities possessed by some of the changes requested by some of them, there would be fewer requests of this nature.

An executive of a prominent motorcoach-building company writes in part

The objection to special equipment is threefold: It increases the cost of production, delays delivery and is hard to service. The present body, as offered by representative manufacturers, is an outgrowth of the demands of operators all over the Country as the result of their experience. Old-time operators are willing to accept the manufacturer's products; it is the men who are new to the motorcoach business who demand that changes be incorporated in the vehicles. Deviations from standard practice that are requested most often are changes in head-room, seats, heating arrangement, windshield, height of step, baggage compartment position of emergency door stanchions, length of frame to accommodate a special body, magnetos and carbureters, and changes in special accessories, such as lighting equipment, horn, and windshield wiper.

There are also constant requests for changes in gear ratio and tires, which are quite legitimate. Requests for changes have not been so frequent in the last 6 months or so as formerly, as the operator is beginning to see that the manufacturer's aim is to build the best motorcoach possible and is therefore willing to accept the result of the manufacturer's experience and experiments. The greatest clamor for changes came from associations and groups of men who met in conference and wanted to suggest something that would cure all of the ills of the industry.

Against and for Standardization

This same executive remarks further

I think it is a mistake to have the Society or any other body try to lay down standard specifications for all jobs. What the State of New Jersey has done in regard to this is an indication of what additional harm can be done. New Jersey's act has cost manufacturing companies considerable money and has done very little to benefit the general public.

As regards service, we have a "service institution" comprising about 95 branches throughout the United States. All of these branches carry a large stock of parts, and in addition supply dealers who operate under them. If every operator thinks he knows of something better than we build or supply to put on our buses, he puts himself in a very bad position to get spare parts when he needs repairs. This applies to the body as well as the chassis, and it is frequently necessary to wait for parts on special jobs that otherwise would be held in stock.

A man with many years' experience in standardization work observes

Standardization provides a desirable basis on which to call for competitive bidding, thus establishing a better basis for understanding between purveyor and buyer. In many instances applied standardization will result in lower overhead costs by making possible reduced personnel, simplified estimating, less cost accounting and correspondence, and by requiring less investment to meet such charges. Sales advantages are the possibilities for quicker deliveries, frequently lower prices and assurance to the customer of quicker and better service for repair or replacement materials.

The dealer is benefited by reduced variety of parts to be carried in stock, thereby requiring less investment by him. He also can give better service and consequently improve his business relations with his customers. The purchaser is given a sense of security in the product he buys, with the knowledge that when he needs service he can get it at reasonable cost and with the least loss of time in the tying-up of his equipment.

One builder of motorcoaches suggests that, if the builders could get together and evolve certain fundamental standards that could be adhered to, it would reduce the cost of the product to the advantage of the customer. He points out, however, that in the purchase of street cars the traction companies have drawn their own specifications and the carbuilders have built to these specifications, charging for the extra work involved, with the result that the street car companies undoubtedly pay large premiums for their own ideas. He feels that it will be most difficult to educate the traction interests to the idea of standardization. One significant statement made by this same man is

We have had requests for various types of construction which we have more or less consistently refused to build. In some cases we have yielded, and in nearly every case we have done so to our sorrow.

Operators' Request Led to Improvement

The chief engineer of a prominent motorcoach company wrote

When we commenced the manufacture of coaches about 3 years ago, we tried to maintain the policy of supplying only our standard design of vehicle. We soon found, however, that it was very difficult to keep to this ideal, due to the great variation of customers' requirements and the different conditions under which the vehicles had to operate. We also found, in some cases, that the customers' special requirements and specifications had decided advantages over our own design, and we then gradually incorporated many of these changes as standard.

As our business became greater and our coaches were distributed to all parts of the Country, we began to collect data as to the requirements of customers and so were able to standardize designs that meet practically everybody's requirements and, as a result, we have now been able to return to our original scheme of supplying only standard vehicles, with a few minor exceptions such as seating arrangements.

Our attitude now is that these standard vehicles are the only type that we are in a position to supply. Of course, a number of minor points are left to the customer's decision, such as color scheme, changes in seating arrangement, make of tires, and extra equipment such as spotlights. Should a special body be required our customers can, and occasionally do, have a special body made by an outside builder and mounted on our standard chassis, but the difference in price between such a special body and a body made as a regular production job in our own factory has become a great deterrent to this practice.

Basic Requirements of the Motorcoach

Having thus ascertained the attitude of various motorcoach manufacturing men toward changes from standard construction, let us consider the fundamental requirements for a motorcoach, which are listed in the Factor column at the left in Table 1.

Steering must be reasonably easy and of sufficient range to permit proper handling in traffic and turning corners with the least effort. Any change to a larger wheel or a slightly increased steering-angle would be of so little value as to be offset by other considerations, such as convenience of service, manufacturing cost and consequent higher first cost.

Brakes must be of sufficient capacity to hold the coach

safely under full load in the kind of service for which it is intended. They should also be consistent, of reasonably long life, should not heat the wheels and tires excessively, and should be easy of operation. Any braking qualities requested in addition to these are only moderately valuable. For example, if a special kind of lining was demanded, it would be necessary for the builder to determine first whether or not he could conscientiously recommend that lining. This might require some expensive testing, even running into thousands of dollars, for, if the builder did not assure himself thoroughly and the brakes did not operate satisfactorily, either at first or later, the operator might lay the blame upon some chassis features, and then the task of proving where the responsibility lay would fall upon the builder.

Besides this possibility, the purchasing, inspection, production, and testing departments would all have to handle the order as special, which would result in a manufacturing cost out of all proportion to that which the operator would think it should be. If an accurate record of cost of this was taken, it would, without doubt, disclose the loss on the transaction to be hundreds of dollars, yet the customer could not understand how the cost could be more than a very small amount compared with the total price of the vehicle. He might not pay for the trouble in the first case, but someone must pay for it some time if the builder is to stay in the business.

TABLE 1—FUNDAMENTAL REQUIREMENTS FOR A MOTORCOACH AND EVALUATION OF THE VARIOUS FACTORS

Factors	Evaluation	Gain or Loss Example 1, Special Power-plant	Gain or Loss Example 2, Reduced Floor Obstruction	Points Example 3, Change to Electric Transmission
Safety				
Ease of Control				
(*a*) Steering	25			
(*b*) Braking	100			+10
(*c*) Gearshift	20	—2		
(*d*) Clutch Action	25	—3		+5
Floor Free from Obstruction	60		+10	—2
Safe Entrance and Exit Conditions	70			
Total for Safety	300			
Comfort				
Smooth Riding	70			
Comfortable Seats for Short Rides	50		+5	—4
Wide Aisles	30			
High Head-Room	40			
Ventilation	40			
Freedom from Objectionable Noise	70	—7		+10
Total for Comfort	300			
Economy				
Large Carrying Capacity per Unit	65			—5
Neat Appearance	45			
Ease of Maintenance	35	—5		
Long Life of Units before Overhaul	55			+3
Economy in Fuel and Oil	35			+2
First Cost	65	—5	—5	—11
Total for Economy	300			
Performance				
Good Acceleration	50			+10
Good Average Speed	50			
Total for Performance	100			
Total for All Requirements	1,000	978	1,010	1,018

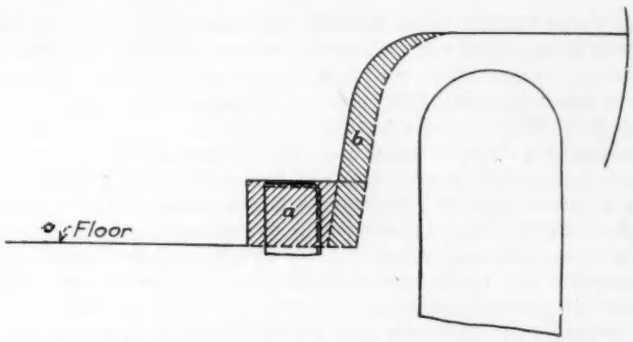

FIG. 1—PROPOSED CHANGE TO REDUCE FLOOR OBSTRUCTION
To Remove Obstruction *a* Caused by the Frame Housing and Reduce the Width of Wheel-Housing *b*, as Shown by the Shaded Portions, Would Require the Designing of New Frame and Axles, Building Samples and Testing Them and the Making of Special Production Patterns and Tools, at an Estimated Total Extra Cost of $313 per Vehicle on an Order for 50 Motorcoaches

A gearshift that is silent, positive and easy to operate fulfills the main requirements. A clutch of adequate capacity in proportion to the engine power-output and the weight of the vehicle, that operates easily, is soft in action and has long life for the particular service meets the main requirements. Relatively few requests for changes pertain to this unit.

COST OF ELIMINATING FLOOR OBSTRUCTIONS

As for obstructions in the floor, if the transmission, wheels, and heating system are arranged so that the necessary housings in the floor are reduced to the minimum number and size and placed so as not to cause accidents or too much discomfort to passengers, it may be said that the coach is 100 per cent commercially perfect in this respect. Care must be exercised to avoid reducing the housings excessively. A single instance will serve to emphasize this point.

A customer asked that a change be made in the chassis frame to eliminate the projection in the floor shown at *a* in Fig. 1. It seemed a reasonable request, and the fact that it was made by an experienced operator lent weight to it, but consider its effects. First, the builder has on hand an ample stock of frames purchased for the purpose of serving customers promptly when they need vehicles. Delivery of coaches to this particular operator is then out of the question until frames of special design are secured. The new design must be developed to the point at which the engineers can pass it to procure a sample for try-out. To secure this sample, an expense of between $1,000 and $2,000 is involved to cover temporary special tools, special forms and hand work. The try-out of the sample frame, when it is delivered, should extend over considerable time and mileage, and this test, if properly made, will cost from $2,000 to $3,000.

Assuming that the test proves the design to be perfect, which is seldom the case, it is then necessary to arrange for production of the frames. Under the conditions, the proper quantity to consider is the number specified in the immediate order, which may be 50. Then the estimated cost of special tools is $4,900, which puts a charge of $98 per job on the cost to the builder. This, together with the cost of engineering and experimental work, would make the increased cost for the special frames alone about $178 per vehicle. The customer hardly can realize that his moderate request would add so much net cost in a single item.

To go further with this concrete example, special axles would be required to carry out in full the operator's desire to minimize the interference with passengers by reducing somewhat the size of the wheelhouse, as shown at *b* in Fig. 1. In this the question of deliveries again becomes a factor. Only a moderate amount of engineering and experimental work is required, costing possibly a total of $1,000. Special patterns and tools will cost about $500. Then there are the inconvenience and consequent extra cost and confusion of running a special job through the axle plant. Therefore, the net increase in cost of special axles would be about $90 per vehicle.

Other items affected and the probable cost of special new ones are: frame brackets, $30; brake rigging, $10; and gas-tank support, $5, making a further increased estimated cost per vehicle of $45.

Summarized, the extra cost for securing only this minor special feature in a lot of 50 motorcoaches would be, per vehicle,

Special Frame	$178
Special Axles	90
Other Special Items	45
Total	$313

Somebody must pay this cost. The operator is reluctant to pay it and if he pays only part of it someone must pay the whole cost eventually, otherwise the builder who assumes such costs cannot stay in business and supply new units when needed in the future.

Factors That Affect Comfort

To continue consideration of the fundamental requirements, the entrance and exit should be constructed so as to avoid the likelihood of passengers tripping, bumping their heads or falling when entering or leaving the vehicle. If these requirements are met fully, there will be few requests for special features in connection with this factor.

The question of smooth riding as a comfort factor is the subject of considerable discussion; however, when the customer has decided upon a chassis that will most nearly meet his demands in riding-qualities, about the only additional features he can reasonably ask for are air springs and balloon tires. These, as produced ready for the market, can be applied readily without much inconvenience to the motorcoach builder.

Seats that hold the average rider in a comfortable and stable position and are spaced so that he is not cramped meet the main requirements, but the seats should have enough padding and spring action so that they will not cause the passenger fatigue during the average ride in the class of service in which the vehicle is used.

In the present stage of motorcoach development, the buyer of equipment has a wide range of choice with respect to seats. Suppliers of seats are going to great lengths to meet the various demands of operators. When these demands become more uniform and production can be standardized, seat costs will be reduced accordingly. Incidental to the cost of seats is the cost and inconvenience to the coach builder of carrying in stock a wide range of styles so that the vehicles called for by each order can be equipped promptly with the particular seat specified.

Specific requirements for aisle width vary with the class of service. Intercity motorcoaches may serve very well with narrow aisles, but city coaches that carry standees or make frequent stops require wide aisles. A coach that is well designed in this respect will not be likely to draw any special demands from the operator.

Head-Room, Ventilation and Noise

In the matter of head-room also the type of service regulates the dimension. Intercity coaches that carry no standees may approximate passenger-car height of top from the floor, while in city service, in which standees are carried, the minimum requirement would, in my judgment, be that 90 to 95 per cent of the passengers served should be able to stand erect without roof interference with the hat.

The first requirement of ventilation is the removal of objectionable odors; second, a change of air often enough to keep it fresh; and third, the accomplishment of this without causing dangerous drafts. It must be admitted that the present state of the art is distinctly wanting in the accomplishment of these basic requirements, nevertheless, special demands by operators in this connection are few. Possibly they should be more insistent in this respect.

Noise and vibration are very annoying to passengers, since human beings are, as a rule, nervous by nature and are made more so by the present-day mode of working and living. One of the principal objections to riding in trolley cars is traceable, I believe, to the numerous and various mechanical or metallic sounds, most of which are objectionable. A motorcoach that is similarly objectionable cannot be regarded as an improved means of passenger transport.

Recent general demands of the riding public, as interpreted by the operators, have brought about a general adoption of the six-cylinder engine as a prime mover. It may be that the demand will go further in this respect and require builders to adopt another type of powerplant that is even smoother and has less vibration before they have been able to recover the development charges on this type of unit and its related parts.

Gradual development of reasonably quiet gear-sets and transmission systems has resulted from the demands of motorcoach riders but there is yet opportunity for further improvement along this line in many installations. This, however, may be effected gradually without burdening either the manufacturer or the operator.

Factors of Operating Economy

Standardization of carrying capacity has been one of the most difficult problems confronting the builder. It has, however, been solved approximately during the last year. After a chassis has been developed for a given capacity with a certain comfortable seating arrangement, it is decidedly impracticable to increase the capacity without giving rise to one or more of four objections: (*a*) discomfort to driver, (*b*) discomfort to passengers, (*c*) excessive overhang of the body, and (*d*) overloading. This fact is supplemental to the cost and inconvenience of redesigning and rearranging the chassis or body.

Pleasing appearance is of major importance in attracting persons who are accustomed to riding in their own cars. It is becoming recognized that one important field for the motorcoach is in competition with the private passenger car. A man who drives or rides to work in his own car a distance of 5 miles at an average cost of 10 cents per mile may be interested in riding in a public coach for from 10 to 25 cents per trip, but to attract him it is necessary to provide a vehicle that is clean and attractive in appearance as well as comfortable and safe. Since the coach builder already has developed

this quality to a high degree to attract intercity patronage, it should be easy to adapt the urban motorcoach for this class of rider. The ultimate in neat and pleasing appearance can be attained, however, only by painstaking design of the coach as a complete unit before manufacture. Features added to a vehicle that already has been designed correctly are often of questionable value, whether recommended by the operator or decided upon by the builder.

Easy Maintenance and Long Life Important

Ease of maintenance is of relative value, of course, but it is my belief that this will be given more study in the future than it has received in the past. Easy replacement of units facilitates keeping the vehicle in operation as an earning unit, although operators, in general, have not come to recognize this fact in their business, as is made evident by the few special demands in this connection. It may be that the builder will have an opportunity to anticipate these demands by gradual development and without unusual costs or inconvenience.

Operators are urging improvement in the lasting qualities of units and I believe that the builders of parts are making extensive efforts to meet the demands. This requirement is accentuated by the increased service to which the units are subjected as a result of the automatic building-up of an ever-increasing traffic following the introduction of the motorcoach. The fact that a unit does not stand-up in one service does not mean that it is not well designed and well built for general conditions. The individual operator usually does not give proper consideration to this fact. If his requirements are unusual, he should realize that the cost of development of special equipment to serve that purpose should be borne by him and that the manufacturer whom he selects as capable of doing the work is entitled to a reasonable profit.

Economy of fuel and oil consumption has a certain relative importance but has been accorded more weight than it has deserved. This does not, however, in any way relieve engineers of the responsibility of striving to keep down the consumption of these items.

The first cost of a motorcoach to the operator is composed of such items as material, labor and factory overhead, which represent production cost; and general overhead, engineering, advertising, selling expense; and profit. All of these items are affected to some extent by changes from standard, some more than others, and the changes invariably result in a higher price or a lower profit, sometimes both. If the operator wants a particular feature incorporated, he should weigh carefully whether or not it really is justified and be willing to pay for it.

Smooth Acceleration and High Speed Wanted

One quality of acceleration is smoothness, and the demands of operators in this respect are being met by the conventional speed-change gear-set in combination with the more powerful engines that have been developed recently. However, one prominent operator, the Philadelphia Rural Transit Co., has gone to the extent of specifying an electric transmission-system for both its single-deck and double-deck coaches. This system provides a maximum smoothness of pick-up. Whether or not demand for this high quality of smoothness will become general remains to be demonstrated.

Acceleration qualities are dependent, of course, upon horsepower, gear-ratios and weight of vehicle. A satisfactory value for city motorcoaches is 1.4 m.p.h. per sec. and for intercity coaches is 1.0 m.p.h. per sec. In the last year or two the development of large six-cylinder engines has improved the quality of acceleration to an extent that is very satisfactory. Demands for further improvement in acceleration may be made but the need for it will have to be proved.

A motorcoach of any design will make a certain average speed in operation on a given route but the coach that will safely make the highest average speed on the route is the one to receive fullest consideration. With suitable brakes and speed changes, the final gear-ratio has most to do with the control of average speed and, since most coach builders are prepared to supply, with little inconvenience, ratios that closely approximate most of the ratios required, the operator needs only to choose the one that is most suitable for his route.

How to Evaluate Desired Changes

When considering any undertaking it is well first to list all of the main factors involved, assign a value to the whole list, and then evaluate each individual factor. If a change in any item is contemplated, the effect of the change upon other factors also may be evaluated and the net result determined. Anyone can make such a chart to suit his own ideas. That shown in Table 1 is an example, not necessarily an ideal one, but it will serve to emphasize the important point that when changes are contemplated they should by all means be considered in the light of how they will affect the whole and not be allowed to become exaggerated out of all proportion to their relative importance.

To illustrate, in Example 1, Table 1, the request for a special powerplant was acceded to by a certain company, with the net result as shown, a loss of 22 points, instead of a desired gain. In Example 2, a change in frame and axles to improve the floor conditions would result in a net gain of 10 points in the vehicle as delivered, a value so small, when properly weighed with the whole, as scarcely to be worthy of consideration. In Example 3, a request for electric transmission, if complied with, would represent a gain of 18 points. The basic values for intercity or de luxe service would be somewhat different than those shown in the table.

In conclusion, I wish to plead with the operator for forebearance in the matter of changes in design or requests for special features until such changes can be given seasoned consideration and a thorough test so that they may in due time become standardized improvements. In this process many ideas or special specifications will prove unimportant and, on the other hand, many worthwhile improvements will result, with the minimum of development charges.

INDUSTRIAL CONDITIONS IN GERMANY

THE future of commerce with an industrial nation like Germany depends, if we get down to fundamentals, upon the relative energy of the engineers of that country and of ours. Previously accepted theories of the political economist have been falsified, and time alone will show what may result from the present, yet, from the mass of figures and other facts provided, some reliable conclusions can be drawn. For the first time in 10 years, dividends are appearing in the German share-market reports, the average return on the capital of 11 metal and engineering companies to the end of March of this year being 6.01 per cent. One of the more striking features of German industry is the way in which combinations are being formed, not merely groups of associated trades, but organizations in the vertical direction as, for instance, an ore-mining company, a coal-mining one, a steel works, a shipbuilding yard, main and auxiliary engine works, electrical works, and the like, combining to form a more or less self-contained unit. In the horizontal direction —groups of similar occupations—this tendency is even more marked, and international combinations are being formed. The electric-lamp producers of different countries are now working together. A similar organization for coal and steel is being advocated in some quarters, over-production and protection compelling attention to such possibilities. Other interesting developments may be found in the agreement of the Westinghouse Electric & Mfg. Co. and the Siemens-Schuckert Co. to exchange the results of all investigations, inventions, experiments, and records of working methods for a period of 10 years. The Motorenwerke Mannheim has arranged to work with the Bethlehem Steel Corporation on a 15 years' agreement, a money advance by the latter and the supply of Diesel engines by the former being two of the conditions. Friederich Krupp A.G., Essen, has amalgamated with two companies in Jugoslavia and has established a number of interests in Spain. A large combination of engineering firms exists to develop trade with Russia, while a 30 years' concesson for railway, structural and agricultural supplies for the Turkish Government has been obtained by Germans.

Germany will practically cease to be a purchaser of British coal in the future. As is well known, there are in Germany not only large coal fields, but great quantities of lignite. It seems possible that the continual experiments being carried out in Germany in the distillation of oil from coal and lignite may result in the development of a commercially-practicable process, which, together with hydroelectric developments, will render Germany independent as regards sources of power.

The labor position appears to be comparatively stabilized. There are no trade-union restrictions on output, and the operatives, particularly in the smaller works, attend the maximum number of machines with good results, while the subject of overtime has never become acute. Piece-work is slowly coming into favor again but, even when wages are increased by 25 per cent over the daily rates by its adoption, the German workman receives only about one-half the wages of his British rival.

Hydroelectric schemes are consistently receiving attention. In Bavaria, for instance, there are under construction plants representing 50,000 hp., and schemes are in progress for another 400,000 hp., which, together with the existing 540,000 hp., accounts for about half the available water-power in that State. Baden has 800,000 hp. available, and is embarking on distribution plants from stations on the Central Alps to the lignite mines of the lower Rhine. Other States are equally active, and the many schemes include extensive railroad electrification.

The manufacture of aluminum is extending. In 1913 the annual production was about 800 tons, in 1924 it was 20,000 tons. The iron and steel industry may be said to be in a fairly satisfactory state, and its activity may be gaged by the fact that Germany is using more of these metals than the United Kingdom, even after the extensive refitting of the inflation periods. The home market is being most assiduously cultivated and 80 per cent of the total production is estimated to go in this direction. It is stated that the acceptance of foreign contracts at cut prices is really based upon the desire to reduce overhead charges, thus helping to keep the large units, which are a feature of German iron and steel plants, running at an economical rate. This policy is helped by the formation of various syndicates that operate in this direction by the transfer of orders to works that can then produce up to their full and most economical capacity.—*Engineering* (London.)

TRAINING OF AUTOMOBILE REPAIRMEN

THE Council of the Institution of Automobile Engineers in a letter recently distributed to the motorcar builders and to the leading automobile repair-shop proprietors of Great Britain emphasize the shortage of really well equipped automobile repairmen and calls attention to the requirements of the future. In this letter the Institution points out that future requirements should receive attention now and that some scheme of training young men to become automobile repairmen as distinct from the practice prevailing in England at present of training them for positions in automobile factories should be undertaken. While the latter type will still be required for the factories and the larger repair shops where the number of men employed permits of each being a specialist in his own particular line, the smaller shops, which furnish the greater part of the service called for by the public, require greater versatility.

The plan proposed by the Institution embraces a course of training that will extend over a period of 5 years and is to be taken at the plant of an automobile builder, in the shops of a large operator of motor vehicles or in a large repair shop. At the end of the course a written examination will be held.

The course is divided into both practical work in the shops and "book" work, the latter including drafting and the study of textbooks in foundry practice, material testing, blacksmithing, and metallurgy as well as a study of the parts of a car, their purpose and construction, and the reasons for the various forms followed. The outline of the practical portion of the course is as follows:

Subject	Months
Machine Shop	9½
Engine Testing	2
Car Testing	2
Showroom	2
Fitting and Assembling	2
Electrical Equipment	3
Tool Storeroom	1
Wheel and Tire Work	1
Coppersmithing	1
Hardening	¼
Welding	¼
Repairs	36

It will be noticed that 3 years, or the greater part of the training period will be spent on actual repair work. In this division of the course special attention will be given to the care of customers' cars in regard to cleanliness when repairs are being made.—*The Motor Trader.*

Fundamental Requirements for Commercial Aviation

By W. B. STOUT[1]

AERONAUTIC MEETING PAPER

THE discussion following the presentation of this paper was constituted of remarks made from the floor at that time and a written contribution that was subsequently received. In accordance with the usual practice, the stenographic report of these remarks has been submitted to the various speakers for their approval and to the author for any additional comment that he cared to make. The corrected discussion, as received, is printed below. An abstract of the paper precedes the discussion so that those of the members who did not read the paper when it was printed in the November, 1925, issue of THE JOURNAL can gather some knowledge of the subjects covered by reading the abstract if they do not wish to take the time to read the complete text.

ABSTRACT

DEFINING a commercial airplane as one that "can support itself in the air financially as well as physically," the author states that when, how and where a plane is used determine whether or not it is a commercial plane. Although some of the old "Jennies" left over from the war have been used with profit in certain narrowly restricted lines of work and the planes used in the Air Mail Service may be regarded as commercial planes, in a sense, the real commercial airplane is one that can earn the greatest dividend under the widest range of conditions. The two fundamentals to be met are the accomplishment of the most ton-miles per horsepower and the most hours per day in the air.

Safety and reliability are essential to the earning of dividends, and the operation of the planes in the air must be supported by an active business organization that will secure sufficient traffic to keep the planes loaded and by a ground organization for the proper maintenance and inspection of the machines.

Two major requirements that must be met before we can have true commercial aviation are a real airplane engine, air cooled, and absolutely dependable navigation apparatus, preferably a radio system. Eventually, planes must be of metal, as high insurance rates will preclude the use of any other kind, particularly for passenger transportation. Large cubic capacity is of prime importance for passenger and express work. Passenger cabins must be roomy but need not have high roofs that will permit of standing up and walking about.

Six requirements for the successful airplane of the future are listed, and, after discussing the type of powerplant needed for airplanes, the author deals with the choice of airplane routes. The highest development of air service will be in intercity passenger and express work, with planes operated at night. At the lower end of the scale will be lines between small remote communities with planes operating in competition with dog teams, pack animals and canoes in territory that is too rugged or otherwise impracticable for other means of quick transportation.

Data on the operation of the Ford airlines between Detroit and Chicago and Detroit and Cleveland during the first six months of service are given, including the carrying of a complete Ford automobile, with body, to Cleveland. The plane used gives excellent service over level terrain but is not adapted for work over mountainous country; such work requires planes with three or more engines to enable them to continue with load even if one of the engines goes dead. A commercial plane must have the same degree of lightness as a military plane but must be more rugged to assure longer life and to keep down the cost of maintenance. Aviation laws and a sufficiency of landing fields cannot bring commercial aviation until we have commercial airplanes.

THE DISCUSSION

QUESTION:—How many hours of flying do you figure on before you absorb the investment in the engine, leaving out the cost of overhaul? About 500 hr.?

MR. STOUT:—Yes. That is equivalent to 50,000 miles. It will be after about four or five overhauls.

QUESTION:—Are these planes for sale generally?

MR. STOUT:—The airplanes are for sale to incorporated airlines, not to individuals, and we must know what they are going to be used for and how. We knew what some of the people who wanted to buy planes intended to use them for, so we did not sell to them.

QUESTION:—What do you think of crash insurance?

MR. STOUT:—I do not think that is covered. The best crash insurance is an organization of good mechanics.

QUESTION:—Is the machine very stable when it is on the ground?

MR. STOUT:—Yes, but we are widening the landing gear by 2 ft., although we have had no trouble with it so far. We have flown passenger trips as well as freight trips with a load as heavy as 2700 lb. When the airline was started the ship was supposed to leave at 12 o'clock. When the ship was ready it was often sent away at 5 min. before 12. We were criticized for that. Mr. Ford said, "If you are to leave at 12 o'clock, leave on the hour." Therefore a bell and an electric light were installed on the field and connected with the Western Union telegraph system. When 12 o'clock comes the bell rings and the lamp is lighted. Then the ship leaves the field and the people in Dearborn and roundabout set their clocks by it.

QUESTION:—How long does it take the pilot to open the window at the front of the fuselage when in flight?

MR. STOUT:—Not more than a second. He pulls a lever and its flies open itself.

ESTIMATED ENGINE AND SHIP DEPRECIATION

QUESTION:—What is the depreciation charge in connection with the operating costs for the ship?

MR. STOUT:—We write off $6.00 per hr. on the engine and estimate that the ship has a life of about 300,000 miles. That is very conservative compared with ships built of wood and cloth that are now flying.

QUESTION:—Do you consider that sufficient?

[1] M.S.A.E.—President, Stout Metal Airplane Co., Airline Division, Ford Motor Co., Dearborn, Mich.

MR. STOUT:—I really think the ships will last twice that long, easily.

QUESTION:—How about engine depreciation?

MR. STOUT:—That is the major part of the cost.

QUESTION:—Is there no figure in the costs to cover loss from possible crashes or anything of that kind?

MR. STOUT:—That is covered by a contingency charge and is included in the figures at a certain rate. Of course, nobody knows yet exactly what it is, because no one has had enough experience, but the company is writing off a charge that it believes is reasonable. Experience is the only thing that can show what the figure should be, and we are getting a great deal of that.

QUESTION:—Are the airplanes covered against crystallization of the metal?

MR. STOUT:—Crystallization in most metals is dependent upon design. If a part is over-stressed, crystallization occurs. If it is not over-stressed, it does not crystallize. There is no more chance of crystallization in a metal airplane than there is in the roof-truss of a powerplant in which there is vibration all of the time. If the vibrations in an airplane are taken care of so that they are not concentrated at any point, there will be no trouble from crystallization.

ROUTINE OF SHIP INSPECTION

W. LAWRENCE LEPAGE[2]:—Can you give us any information regarding the inspection routine and the period between inspections under the schedule of arrangements for the airlines?

MR. STOUT:—We have a large printed sheet which includes almost everything in the airplane that anyone in the Ford Motor Co. could think of, and an inspection man goes into the ship with a spot-light and examines each item. Another man with him checks off the items on the sheet as they are examined. The two men go over everything after every trip. One feature of the ship is that there is not a single rivet in it that cannot be inspected. The men go over the wings, inside and outside, as well as through the rest of the ship.

MR. LEPAGE:—How long does that take?

MR. STOUT:—I should say an hour. Particular attention is paid to the controls, of course.

QUESTION:—What is the fuel consumption?

MR. STOUT:—It is about 1 gal. to 4 miles. We run a little under 25 gal. for slightly more than 100 miles in an hour.

QUESTION:—Does your own company remodel the Liberty-12 engines that are used in the airplanes?

MR. STOUT:—They are all rebuilt by us to conform to the latest standards. We change the gears and carbureter and ignition and make all other changes needed to bring them uptodate.

QUESTION:—Do you take the regular Army equipment?

MR. STOUT:—The regular Ford Liberty-12 engine, yes.

QUESTION:—Do you do that work in your own factory?

MR. STOUT:—It is done at the Ford Motor Co.'s Dearborn plant right next to our factory.

QUESTION:—What is the cost of the engine to you after those improvements are made?

MR. STOUT:—The price of the engine is about $2,000. Another $1,000 can be added to that for the overhaul, shipping, inspection and other things of that kind. The cost is really $3,000 when the work is finished. The engine is installed in the airplane in a separate nose-unit that includes all of the engine instruments and controls. It is only necessary to disconnect the gasoline line and remove four bolts to take out the engine and put in another one. That is quick replacement.

MR. LEPAGE:—The question of inspection is a most important one. Is it in order for us to hear from Colonel Henderson just what the inspection routine is in the Air Mail Service?

INSPECTION SYSTEM OF AIR MAIL SERVICE

CHAIRMAN PAUL HENDERSON[3]:—I think that the Air Mail inspection routine probably is not unlike that described by Mr. Stout, except for the very definite fact that we are dealing with the wood and stick fuselages and the inspection of the fuselage itself probably has to be much more thorough than the inspection of Mr. Stout's metal fuselage. For much of the fuselage inspection that his men can make visually and without taking anything apart, the Air Mail inspector has to get inside to make.

There are 100 items on the Air Mail inspection card, about 40 of which relate to the engine and 60 of which relate to the fuselage, wings and landing gear. The system is like the Stout system in that each item is checked by one man and then re-checked by a second man. In the Air Mail Service they go a step further. The pilot has the right to question the inspection of either of those men and to demand a new inspection if, in his judgment, the first inspection was made by men in whom he does not have confidence. The pilot is held responsible for the final inspection. He bases his decision as to whether or not the inspection has been thoroughly made on his knowledge of the individuals who sign the inspection card.

SELLING PRICE OF STOUT AIRPLANES

QUESTION:—At what price do you estimate you can sell the Stout machine now and to what extent do you think the selling price will be reduced within the next 2 or 3 years?

MR. STOUT:—That depends largely upon how the industry develops. The price that has been fixed to date is $22,500, including the engine and all. As production increases, that price will come down, I think, to about $15,000 without the engine. Then the buyer can select his engine, whether it is one or three, or whatever number the particular airline requires, and the total price will depend upon the engine or engines.

QUESTION:—The Liberty-12 engines originally cost about $6,000.

MR. STOUT:—If a new engine were available now we would not give $1,000 for the Liberty engine, because so many engines are being developed that are much better. The reason we are using the Liberty engine is that it is the only engine that is available at anywhere near the price. I think that within a year very few water-cooled engines will be used except possibly in pursuit work. I may be wrong, but that is my belief.

CHAIRMAN HENDERSON:—I have recently made a rather exhaustive study of the subject of depreciation and the lowest depreciation figure that I feel justified in using, under present conditions with Liberty engines and a steel-tube fuselage, is between $22 and $27 per hr. in flight. I use the hour as a unit because it seems to me to be the fairest sort of unit to deal with. An airplane wears out in proportion to the number of hours it is flown. Of that $22 to $27, about $7.50 represented engine depreciation, which Mr. Stout estimates at $6.00.

[2] Jun. S.A.E.—Editor *Aviation*, New York City.

[3] General manager, National Air Transport, Inc., Chicago.

Fixed Charges about $75 per Hr.

Lieut. H. R. Harris[4]:—I must congratulate Mr. Stout upon his excellent paper. Anybody who can work up cost figures as cleverly as the Ford Company has done is deserving of the highest praise. Our fixed charges are in the vicinity of $75 per hr. That includes insurance, depreciation and interest on investment. I do not see how Mr. Stout can operate his airplanes as cheaply as the Ford people figure that he is doing.

Chairman Henderson:—For the benefit of those who do not know, I will say that Lieutenant Harris is connected with the Huff-Daland Dusters, Inc., which is engaged in the new business of dusting cotton fields with a powder that is destructive to the boll wevil, and they are very successful in it.

A Member:—Mr. Stout's statement that every rivet in the wings of his airplanes can be inspected is of special interest. In the ordinary wooden wing that is covered with fabric hardly anything can be inspected.

Question:—Mr. Stout claims that alloy steels have a minor place in airplane construction. Will he explain why?

Mr. Stout:—I can give only my own analysis. There is an important factor to consider in the building of the larger ships, and that is the expansion coefficient. When steel spars and duralumin covering are used there is considerable difference in expansion in the high and low temperatures which is likely to produce unknown stresses in the structure, hence we prefer to make our frame and cover all of duralumin and know that, whatever the temperature, the stresses throughout the structure are always the same.

A Member:—What is the maximum gross weight of one of these ships that flies about 4 miles per gal. of gasoline, and also what is the maximum possible load?

Mr. Stout:—The weight of the ship, with water, is 3750 lb. We have been carrying as much as 2750 lb. of load commercially. We never have tried to determine the maximum possible load, but we have a considerable margin left even when carrying 2750 lb. The proof of the claims for comparatively low horsepower-requirement is the fact that we are using the old deHaviland radiator which proved to be too small for the deHaviland airplane, and have been using it even in the hottest summer weather without having cooling difficulties.

Ford Cost Figures Questioned

Archibald Black[5]:—Mr. Stout's conclusions regarding the requirements of transport airplanes are about the same, in general, as those arrived at by others of us who have studied the same problem. However, the ability to operate 20 hr. per day is dependent more upon the traffic available than upon the capability of the airplane. Present airplanes can be flown 20 hr. per day if enough passengers or freight can be obtained to make it commercially practical. The only necessary departure from customary practice would be that of providing four or five pilots for each machine and changing the pilot every 4 hr. or so at intermediate stops.

The question of designed flight-duration is tied up very closely with the work to which the airplane is to be put. It does not seem very advisable to lay down generalizations such as Mr. Stout's minimum of a 5 or 6-hr. supply of fuel. The pay load is lessened 1 lb. for every pound of fuel carried. In making studies of this phase, we have found that it becomes very serious after a flight of 4 to 5 hr. at high speed. Mr. Stout's duration figures would seem more appropriate as maxima rather than minima. It would seem better, however, to say that the fuel capacity should be as little as safe operation on the route will permit.

It will be evident to anyone who is somewhat familiar with airplane operating costs that something is radically wrong with the Ford cost figures. Having given more attention to the costs of airplane maintenance and operation probably than any other engineer in this Country, I am curious to know how the figure of 36 cents per airplane-mile was obtained. In the absence of a detailed statement, it is difficult to point out omissions or inaccuracies in the method of calculation. By way of comparison, however, it may be noted that the Air Mail Service costs for the fiscal year 1925 were $0.991 per airplane mile. This service is operated with the same Liberty-12 engine as the Ford Motor Co. uses in the Stout airplane. Ordinarily, the two costs should be directly comparable, but the Government system of accounting and the fact that the Post Office pays no taxes, insurance, commercial costs and many other items, actually results in cost figures that include approximately two-thirds of the total charges which a commercial enterprise would have to pay. Against this can be balanced only the moderate increase in efficiency that is possible as a result of commercial operation. European air-transport costs have very little, if any, value as applied to conditions in the United States. However, if anyone should be curious to know, I may mention that the Compagnie Internationale de Navigation Aerienne, formerly the Compagnie Franco-Roumaine, operates at slightly more than $1.00 per airplane-mile under European conditions. This figure includes all charges.

After several years' study of maintenance and operating costs in the United States, I can say safely that the figures for operation of the Ford airlines on the present scale must be multiplied by 3 or 4 to give the true cost on a business basis. Any experienced operator will agree with this statement. Explanation of the figures probably lies in the Ford company's very limited operating experience in this field. At the time of calculating the Ford airline costs the service had been in operation only a few months. Certainly that period would seem much too short a time in which to attempt to revolutionize the business of operating airplanes commercially.

[4] A.S.A.E.—General manager, Huff-Daland Dusters, Inc., Monroe, La.

[5] M.S.A.E.—Consulting aircraft engineer, Garden City, N. Y.

Recalescence of Steel

PHASES of transformation of steel are illustrated diagrammatically in the accompanying curve where *OX* and *OY* represent temperatures and elongation respectively. If a steel bar be heated from 0 deg. cent. (32 deg. fahr.) up to about 700 deg. cent. (1292 deg. fahr.) and the points

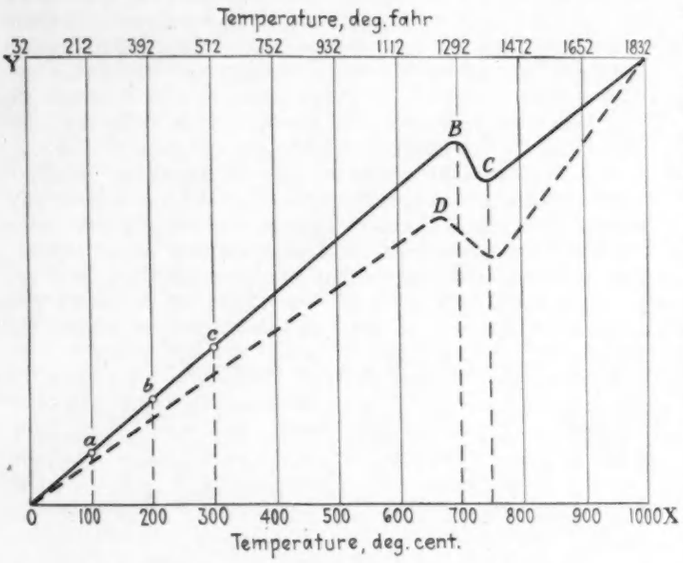

DIAGRAM ILLUSTRATING PHASES IN THE TRANSFORMATION OF STEEL

corresponding with the rate of expansion set out as *a*, *b* and *c*, it will be found that a progressive curve, *A B*, is obtained. At about 700 deg. cent. (1292 deg. fahr.) a sudden drop occurs in this line, the lowest point being *C*, corresponding to a temperature of 750 deg. cent. (1382 deg. fahr.). If the specimen be further heated up to 1000 deg. cent. (1832 deg. fahr.), it will be found that the curve again rises progressively in proportion to the temperature.

If the bar be now allowed to cool down slowly, it will be found that it contracts progressively at approximately the same rate as that at which it previously expanded. Between 750 and 650 deg. cent. (1382 and 1202 deg. fahr.), however, it suddenly expands, after which contraction again sets in uniformly until the bar regains its initial length at 0 deg. cent. (32 deg. fahr.). From the dotted curve, it will be noticed that contraction takes place at a lower rate below the point *D* than above the expansion period. If the cooling process be carried out in the dark, it will be observed that the color gradually darkens until the 750 deg. cent. (1382 deg. fahr.) point is reached, when the specimen visibly brightens throughout the expansion period, darkening again when the point *D* is passed. This is the real recalescence of the steel. *B* is the point of heating transformation and that on the lower curve, corresponding with *C*, the point of cooling transformation. It should be noticed that these transformations are reversible. Point *B* is of such importance that it becomes an influential factor in a steel's specification and a ready means of testing its quality. During this transformation period a steel is no longer attracted by a magnet, this temporary loss of magnetic property showing that some special phenomenon is taking place.—Prof. R. E. Mathot in *Automobile Engineer*.

NATIONAL COMMITTEE ON WOOD UTILIZATION

SECRETARY HOOVER, chairman of the National Committee on Wood Utilization, has called a meeting of the members for April 28 at the City of Washington. This Committee, which was established by direction of President Coolidge, is composed of important consumers, distributers and manufacturers of wood and wood products. Its vice-chairman is William B. Greeley, forester of the United States.

"Utilize wood and save our forests," is the slogan of the Committee. According to Axel H. Oxholm, director of the Committee, proper utilization of the greatest portion of every tree felled would mean an extension of the life of our forest resources to meet the time when our second-growth forests mature. The failure to utilize our forest products properly has caused a heavy drain on our timber stands. Heretofore we have marketed from 25 to 35 per cent of the standing tree, taking the Country as a whole. This has been due largely to the fact that most consumers are still adhering to the specifications and the quality requirements that prevailed in the days when timber was cheap and plentiful.

The Committee believes that "wood waste" is a misnomer. Convinced that every part of the tree can eventually be used as lumber or manufactured wood products, its work will extend into the manufacture of lumber, pulp, paper, wood chemicals, naval stores, charcoal, composition board, and other by-product possibilities. The broader standardization of grades and sizes, trade extension, educational efforts, and the application of scientific findings to production and marketing of wood products will be considered. Building and construction, being the largest consumers of wood, will receive special attention and investigations will be made for the purpose of creating a larger demand and use of all qualities and sizes of lumber produced. Special subcommittees will be formed to aid other industries such as railroads, furniture and automotive factories, mines, and other wood users.

The Committee has been urged to devise means and methods whereby transportation and distribution of lumber and wood products will be effected in a more efficient and economical way. This is a factor of vital importance in view of the ever-increasing distances of the source of lumber supply from the consuming centers. Efficient logging, saw mill and woodworking practices will also receive careful study.

The aim of the Committee is that more and better lumber and wood products shall be produced from each tree, thereby effecting a saving in the number of trees necessary to cut to supply the Nation's timber needs. As a result, commercial reforestation will receive added impetus. Wood is one of our most essential raw materials and is used by every industry. With the perpetuation of our National forest resources, one of the vital requirements of the Country will be assured.

Correct Carbureter Adjustment and Improper-Adjustment Effects

By O. H. Ensign[1]

Southern California Section Paper

ABSTRACT

HANDICAPS to proper carbureter-adjustment, due to the inability of the user to recognize from what happens on the road the cause of carbureter trouble, or of other engine trouble that may be blamed upon the carbureter, are emphasized by the author, who mentions also the tendency in modern engine-practice toward the hot-spot as the main source of fuel-mixture heat and the attainment of maximum power by adjustment that secures the proper relation between fuel-mixture temperature and cooling-water temperature. After discussing the conditions that control power-output, a general method of adjustment that can be applied with certainty to any installation is presented.

In outline, the method is to make all adjustments following a considerable period of operation that produces an established heat throughout the entire powerplant, making the maximum-power adjustment on a grade that will hold the car at some desired speed slightly in excess of the maximum legal speed-limits, with wide-open throttle, and accomplishing other adjustments during numerous runs on two other grades, one being steep enough to hold the car at about one-half speed and the other of a steepness that permits a satisfactory low-speed car-travel with wide-open throttle.

Idling considerations are discussed and some of the phenomena occurring during the warming-up of an engine are analyzed. Over-rich fuel-mixtures and the tendencies thereto are treated, and the effects of fuel-mixture heating are summarized.

NO subject likely to be discussed by the average person who may have contact with such a device gives rise to more misleading assumptions and wrong conclusions than carbureters. As described by the average owner who desires to have carbureter adjustment made, even when discussing fuel-economy, it is almost impossible to determine what may be the trouble with a carbureter from any description he gives of what happens on the road. It is unfortunate that no definite carbureter phraseology has been developed and used universally. For instance, the terms "choking," "sneezing" and "coughing," as used by the average operator, may refer to almost any sound coming from the carbureter or from the exhaust or to no sound at all. Considering such lack of ability on the part of the user to recognize what may be the cause of carbureter trouble or other engine trouble that may be blamed upon the carbureter, it is therefore natural that improper carbureter-adjustments are exceedingly common.

We cannot discuss the subject of this paper without referring to the technical phases of carburetion in connection with engine tests. One may find at filling stations gasolines having distillation-curve characteristics ranging between the extremes of 90 and 450 deg. fahr. Most of the gasoline fuel supplied can be expected to have a practical range of boiling-points extending from 150 to 400 deg. fahr. or more. It has been shown that such a fuel requires the temperature of the air entering the carbureter to be at least as high as 84 deg. fahr., with the engine's cooling-water temperature at 200 deg. fahr., as the temperature limits which will give reasonably good performance. If the water temperature is lowered, the air temperature must be raised or an equivalent hot-spot must be provided. For instance, another extreme range of temperature may be: Cooling-water outlet, 120 deg. fahr. and air inlet, 150 deg. fahr., with a small hot-spot in the manifold.

Modern engine-practice has tended toward the hot-spot as the main source of fuel-mixture heat, and maximum power is attained by adjustment to secure the proper relation between fuel-mixture temperature and cooling-water temperature; however, this absolute maximum holds good for a particular temperature of the atmospheric air only. With the present fuel such a practice, which aims at maximum power as the prime requisite, always produces a wet mixture; that is, the mixture stream through the manifold and into the cylinder will carry microscopic particles of fuel in suspension. With wide-open or nearly wide-open throttle, a film of liquid fuel of considerable thickness will be deposited on the walls of the manifold so that the bulk of the vaporizing will occur upon contact of the mixture with the hot exhaust-gas remaining in the cylinder, upon contact with cylinder-walls and piston-heads and, after the mixture is locked in the cylinders, due to the heat of compression. No objection attaches to this method, provided the design of the manifold is such that it will give good distribution and that the mixture proportion is the correct one to use.

Power Output

Trucks, motorcoaches and automobiles are operating most of the time at or under one-half throttle or under one-half load. By "load", full load at wide-open throttle at any speed is meant, the fractional load in this discussion always meaning load controlled by throttle position. It is common knowledge that at any part-throttle opening, especially around one-half load, the mixture can be rich in excess fuel and yet show but a very small reduction in power output. C. S. Kegerreis has done valuable work at Purdue University in demonstrating the extent of this phase of engine performance. He has shown that, at one-half load and at engine speeds varying from 400 to 1600 r.p.m., there is a very slight change in power output with a mixture proportion running from 0.07 lb. of fuel per lb. of air, as compared with a mixture of 0.11 lb. of fuel per lb. of air, or a fuel-air ratio varying between 14 to 1 and 9 to 1, which means that a mixture 50 per cent too rich shows very little loss of power, and this is true also at full load but to a lesser extent. This peculiar action of the fuel mixture in the engine is one of the factors tending toward lack of economy; for it is, at least, not uncommon to test the mixture by setting the throttle at part-open position to give the engine a relatively high free-speed, and to adjust the carbureter mixture to obtain maximum engine-speed at that throttle position. It is seen by these laboratory-test results

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that, in most cases at least, it is almost impossible to determine the correct mixture-setting by free operation of the engine, and it even results in a poor approximation.

It is also common knowledge that, at any fractional load controlled by the throttle, the maximum economy with proper engine and mixture temperatures can be obtained with the leanest mixture that will fire evenly in all cylinders, while maximum power always requires a mixture somewhat richer than a perfect chemical mixture. It is very difficult to produce with a carbureter the curve of such a mixture, but it can be approximated by the so-called economizer-attachment built into the carbureter. The economizer operation brings up another difficulty regarding easy adjustment, as all "free" and load adjustments for power must be made outside the range of the economizer operation; for, if adjusted with the throttle in a position that brings the economizer into operation, the tendency is toward a rich mixture.

General Method of Adjustment

Having outlined a few of the factors bearing on the controlling limits, I will endeavor to outline a method of adjustment procedure that can be applied with certainty to any installation. In my approach to this subject, I have assumed that the carbureter as applied to the engine is developed so as to give the correct load-mixture at all speeds and that the powerplant is a high-grade product, already in service some time and broken-in.

(1) Due to the influence of heat on the effective work of the mixture, all adjustments must be made after a considerable period of operation so that a stable heat can be attained throughout the entire powerplant

(2) The maximum-power adjustment should be made on a grade that will hold the car at some desired speed slightly above the maximum legal speed-limits, with wide-open throttle. In the case of trucks fitted with a governor, the grade should hold the loaded truck to a speed that holds the governor almost wide open

(3) Two other hills should be selected; one to hold the car or truck at approximately one-half speed, and the other to hold it at a satisfactory low-speed lug, with wide-open throttle.

(4) A number of runs on each of the grades should be made, at the same starting speed, with small differences in carbureter adjustment, noting the speed at the top observation-point and striving by adjustment to obtain the thinnest mixture that will produce maximum speed at the top. If the adjustment giving the maximum speed at the lesser grade needs to be changed to produce the maximum speed at the steeper grade, this indicates a faulty metering-curve and the local carbureter service-station should be required to correct the difficulty

(5) Slow-speed or heavy-duty engines are easier to adjust than others. Great care must be used in making the adjustment for high-speed engines, because the mixture adjustment for the high-speed engine is more critical and a mixture more nearly perfect chemically must be secured, since combustion must be completed in a much shorter time; therefore, one must be positively sure that settled heat-conditions have been realized fully. High-speed engine tests show that, unless adjustment is made carefully, the high-speed engine will be left with too rich a mixture.

It is realized that the foregoing method will secure the thinnest maximum-power mixture for the condition of normal heat in the powerplant and, when the plant is cold, the starting choke or other means of enrichment must be used for a short time until fair operation can be obtained without it. However, I believe that it is the best and the only reliable method. In a level region, the only process that can take the place of such a procedure is to adjust for the thinnest power-mixture that will give reasonable performance; in fact, it should be slightly under maximum performance, for the maximum is seldom called for in such a region.

Idling Considerations

We have all been inclined to pride ourselves on extremely slow speed for idling operation. In my opinion, that has been the cause of a considerable amount of engine trouble. Slow-speed idling requires a mixture the combustion of which has been delayed by enrichment, and it will produce more soot and carbon than is true of some other causes. It calls also for more "accelerating well" to obtain desirable get-away, which, if not supplied in an ideal manner, will tend to cause the driver to open-up the main mixture to produce pick-up, and thus decrease the fuel-economy. We have heard much about the damage done by improper handling of the starting choke but, with a mixture set on the lean side and the choke used properly in starting, one has an ideal method of operation.

Too rich a mixture will result in low fuel-economy, but the indirect results probably are a greater source of expense than the extra fuel used, since it means more carbon, more valve grinding, greater wear on cylinders and pistons, and greater crankcase-oil dilution with all its attendant evils. In fact, my experience has shown that a mixture at once leaner than at maximum power and hotter than would give maximum power will earn more money for the owner by saving money on repairs than he could make by the trifling addition in power gained in having a maximum all-round power-output, for it is not necessary to favor the lean adjustment far enough to make it possible to detect the loss in power except by careful observation. A frequent cause of poor fuel-economy is some sort of failure of the device used on the carbureter for furnishing accelerating fuel. Such a failure causes the driver to open-up the main mixture to handle the car safely. The ideal job is one that is fairly lean through the part-throttle range and suitably rich at wide-open throttle, with ample "accelerating well" available for pick-up at any speed in the low-speed range.

The careful procedure already outlined for obtaining adjustment will be criticized as more expensive than the damage, but that is not true for, if it is followed regularly and the carbureter is sealed against tampering, the time out of service for repairs in a commercial organization will be reduced remarkably, to say nothing of reducing the cost of these repairs. Many will claim also that the procedure is not necessary, but suppose we consider for a moment some of the easily observed phenomena of warming-up as a means of familiarizing ourselves with what occurs if we do not use extreme care.

Warming-Up Phenomena

All know, when a car is delivering fairly good fuel-economy, that during the warming-up period on the road frequent backfires in the carbureter occur at first if the choke is not adjusted properly when the engine is cold. Analyzing what that backfire means, the facts are that the combustion is so slow because of the cold poorly

vaporized mixture that flame endures throughout the power stroke of the piston after ignition, continues throughout the exhaust stroke and is still existent when the intake-valve opens; thus, it causes ignition of the incoming mixture. A properly adjusted choke adds sufficient additional fuel to provide enough of the low-boiling-point part of the fuel to cause more rapid burning in the cylinders and, at the added depression caused by the partly closed choke, it aids vaporization and produces good performance without backfire. All have noted also that the backfires mentioned are not close together, are not very violent and do not occur at each intake-valve opening. The reason is that the progress of the flame caused by the backfire through the manifold vaporizes the excessive amount of liquid fuel in the manifold; the enrichment thus produced smothers the flame and prevents a violent explosion in the carbureter and, for an instant, furnishes a rapid-burning mixture to the cylinders so that another backfire does not follow immediately. As the engine warms-up, the slow combustion in the cylinders becomes more and more rapid until it reaches the designed rate, which causes combustion to be completed at constant volume when the piston is at the top of the stroke, which is the condition for maximum economy.

Over-Rich Fuel-Mixtures

I have shown that almost as much power can be obtained with a mixture in the range of 50 per cent too rich as with a correct mixture. Such a mixture will cause combustion to continue to nearly full stroke, and the power will be developed in spite of excess fuel by the effect of the "after-burning" on the expansion of the burning gases over the entire length of the stroke. The latent heat of evaporation of the excess fuel prevents the hot-spot from doing its work properly and, instead of a snappy hot-mixture, there is a cold mixture and slow burning in the cylinder, the flame extending through the exhaust-valves into the exhaust-manifold and causing serious damage along the entire route. So, unless frequent attempts to thin the mixture are made under the loaded condition with an established or settled temperature, one is very likely to leave the mixture too rich because the power and the operating ability has been obtained by a mixture that is too rich. In fact, the correct mixture having the leaner value will warm-up as quickly or more quickly than the too-rich mixture, for the rich mixture chills the manifold so much that it is slow in coming to a practical operating-temperature. Most of the hot-spot designs are arranged so that they receive the bulk of the unvaporized fuels and, if the mixture is correctly lean, the after-burning caused by the slow combustion of the cold lean mixture heats-up the hot-spot quickly and it rapidly produces the desired results as to mixture and performance.

Effects of Heating the Fuel-Mixture

It always must be understood that a definite relation exists between the heat of the mixture and fuel-economy and performance. In my opinion, the best simple method of heating the mixture is one that uses the hot-spot for normal summer weather and is provided with air-heating means to supplement the hot-spot for colder conditions. Many, no doubt, have noticed that, at a certain point in the warming-up period, partly closing the throttle will speed-up the car. Assuming always that the metering curve is correct, the foregoing phenomenon means that, under the peculiar condition occurring at that time, the mixture is not hot enough; but closing the throttle changes the vaporizing temperature to a lower degree by increasing the depression on the fuel in the mixture, and better vaporizing occurs with better distribution and more rapid combustion, developing more power. If this condition still occurs after the powerplant has reached an established or stable temperature, more heat is needed for that particular atmospheric-air temperature and this heat should be provided by adding hot air to the hot-spot equipment. It must be remembered that high fuel-economy and maximum power always are obtained more nearly when combustion is rapid and is finished before the piston moves far on the downward stroke, and this condition can be obtained with modern gasoline only by the addition of the correct amount of heat to whatever atomizing means may be provided by the carbureter or the manifold. It is therefore evident that adjusting a carbureter is not so simple a matter as it is sometimes thought to be. If a driver makes his own carbureter adjustment, a good rule to follow is to continue to thin the maximum power-mixture when the car is hot and on a hill, until the power has been reduced slightly.

CONSUMPTION OF FUEL OIL BY LOCOMOTIVES

ACCORDING to returns from the railroads of the United States, a total of 59,355,000 bbl. of fuel oil was burned by the locomotives of the principal roads of this country in 1925. This total includes the fuel oil consumed in all classes of service and compares with a consumption of 61,738,000 bbl. in 1924. These figures are practically complete for all railroads burning fuel oil, only a few small lines consuming very little oil having failed to make returns. The total consumption of 59,355,000 bbl. in 1925 was made up of 54,075,000 bbl. produced in this Country and 5,280,000 bbl. imported. In 1924, 51,522,000 bbl. of the total consumption of 61,738,000 bbl. was domestic fuel oil and 10,216,000 bbl. was of foreign production.

The largest consumption of fuel oil was in the Middle Western and Southwestern district, totaling 27,386,000 bbl. in 1925 and being divided into 24,573,000 bbl. of domestic and 2,813,000 bbl. of foreign fuel oil. This compares with 29,153,000 bbl. in 1924 of which 21,049,000 bbl. was domestic and 8,104,000 bbl. was foreign fuel oil. In the Southwestern Pacific district consumption aggregated 22,940,000 bbl. in 1925 as against 23,924,000 bbl. in the previous year, all of this being domestic product in both years. The 1925 consumption in the Northwestern district was 6,637,000 bbl., of which 82,000 bbl. was foreign oil as compared with 518,000 bbl. in 1924 out of a 7,060,000-bbl. total consumption. The locomotives in the Southern district burned foreign oil exclusively in both 1925 and 1924, the figures for the two years being 2,278,000 and 1,470,000 bbl. respectively. In the Eastern district the consumption totaled 114,000 bbl. in 1925 and 131,000 bbl. in 1924. The quantity of foreign oil used in this district in both years was the same, 7,000 bbl.—From *American Petroleum Institute Bulletin* No. 16.

COST OF GOVERNMENT

THE total cost of government in this Country, covering the expenditures of Federal, State and local governmental authorities and including capital outlays, amounted to $10,252,000,000 in 1924, as against $2,919,000,000 in 1913, according to a report on the Cost of Government in the United States, published by the National Industrial Conference Board, New York City. While there was a decrease of $385,000,000, or of 10.6 per cent, in the expenditures of the Federal Government in 1924, State and local governments increased their outlay by $492,000,000, or 7.6 per cent, leaving a net increase of $107,000,000 in total governmental expenditures.

Taxation figures do not present a complete account of the real financial burdens assumed by citizens through public expenditures from year to year, as becomes apparent in comparing the total taxes raised in 1924, amounting to $7,907,000,000, with the total of expenditures, amounting to $10,252,000,000. While it is true that in the long-run expenditures and taxes go hand in hand, the proceeds of loans, made use of by municipalities and States to an increasing degree in the last few years, may create a great disparity between taxes and expenditures for the time being. In 1924, local governments were responsible for 52.7 per cent, or more than half, of total public expenditures but raised only 47.4 per cent, or less than half, of the total taxes; State governments, likewise, spent 15.5 per cent of the aggregate of 1924 expenditures, while raising only 13.5 per cent of the total of that year's tax levy. The Federal Government, on the other hand, was responsible for 31.8 per cent, or less than one-third, of all public expenditures in 1924 but raised 39.1 per cent of all taxation. In this, the Conference Board points out, is clearly reflected the increasing use of bond issues to finance additional expenditures by States and municipalities, while the Federal Government is not only not incurring any fresh indebtedness but is paying off its indebtedness by spending less than the amount raised by taxation.

Although New York State pays the highest per capita Federal tax, amounting to more than double the average for the Country, and contributes by far the largest amount annually to the upkeep of the Federal Government, the people of Florida, Michigan, Delaware, North and South Dakota, and Utah bear a heavier total tax burden in proportion to their income. The people of Wyoming enjoy the lightest tax-burden in the Country, their total tax bill for all governmental expenditures amounting to only $15,094,000, representing 9.59 per cent of their total income.

The bulk of Federal taxes consists of income tax payments, and most of agricultural income is exempt from income taxation by reason of personal exemptions. Five leading industrial States, New York, Pennsylvania, Illinois, Massachusetts, and Ohio, paid 51.3 per cent, or more than half, of all Federal taxes in 1919, and 49.0 per cent, or a little less than half, in 1924. Including five additional industrial States, Michigan, California, New Jersey, Missouri, and Wisconsin, the 10 leading manufacturing commonwealths have paid two-thirds of the total Federal tax bill in the 5-year period of 1919 to 1924.

The total tax burden of the agricultural States remains high in proportion to income. This, the Conference Board points out, on one hand reflects the benefits derived by the industrial States from recent Federal tax reduction, and, on the other hand, the rising expenditures of State and local administrations, that form the larger portion of the total tax burden in agricultural communities. Agricultural depression, as in North and South Dakota and Minnesota, has further aggravated the burdensomeness of taxation in these States because of reduced income.—*Economic World.*

THE WELDING OF ALUMINUM

DESPITE the fact that the welding of aluminum has been regarded as one of the most difficult of crafts, successful work is commonly done in many applications. The reason for the belief that a long period of training and experience is essential to the production of successful work is due entirely to the characteristics of the material being so different from those of steel, cast iron and other metals, with the treatment of which the general welder is familiar. Explanations of the many peculiar physical actions taking place during the welding of aluminum were given at a meeting of the British Acetylene and Welding Association by Edgar T. Painton, of the British Aluminum Co., Ltd.

The fundamental source of difficulty in the welding of thin sheets, not suitable for the simple pressure welding used in connecting electrical wires and cables of aluminum, was stated to be the rapidity with which the metal oxidizes and the toughness and tenacity of the oxide film that is formed. In the simple butt-welding process, the oxide skin was broken by the application of the pressure. Once the ends of the rods were heated to the melting-point, the metal was prevented from falling away by the oxide skin, which, however, was ruptured and allowed the clean metal in each part to come into association as soon as the pressure was put on. This mechanical process had its counterpart in oxyacetylene welding, in the removal of the oxide as it was formed by the so-called puddling method. One disadvantage that had to be contended with was that the oxide of aluminum has a higher specific gravity than the metal and tended to sink to the bottom of the pool of metal. There was consequently great risk of inclusions within the metal after solidification was completed.

The most effective way of removing the oxide in an aluminum weld was by the use of a flux. While aluminum oxide was not acted upon by many chemical reagents, it had been known, since the beginning of the aluminum industry, that the oxide could be dissolved by molten halogen salts of the alkaline metals. Cryolite, a natural double fluoride of sodium and aluminum, proved a useful component of many fluxes for the purpose, but other fluorides and chlorides were mixed with it to vary the melting-point, the viscosity of the molten flux, its density, and the speed of action. Lithium chloride, for example, was nearly always a component, since it has a very low melting-point and produces a flux that is liquid and flows freely before the aluminum itself reaches its melting-point. An aluminum flux should not be too fluid, however, as under the blast of the blowpipe it may spread and leave too little on the weld to perform the work of removing the oxide successfully. For aircraft work a flux was used consisting of 45 parts of potassium chloride, 30 parts of sodium chloride, 15 parts of lithium chloride, 7 parts of potassium fluoride, and 3 parts of potassium bisulphate. This is a good flux for all general purposes, but many different mixtures on the market have adherents. All aluminum fluxes are hygroscopic and have to be kept in airtight containers. Dr. Briscoe and Captain Richardson discovered that the use of pyrosulphate or pyrophosphate in the mixture prevents the dissociation of the components, and thus it was possible to provide a flux that could be stored for long periods without deterioration.—*Engineering* (London).

Progress in the Measurement of Motor-Fuel Volatility

By T. S. Sligh, Jr.[1]

Annual Meeting Paper *Illustrated with* Diagrams

ABSTRACT

LABORATORY test-methods of indicating the volatility characteristics and the starting capability of fuels used in internal-combustion engines are described, together with the testing apparatus and procedure, the objective having been the development of a simple method or methods of measuring the volatility of individual samples of motor fuel. The requirements are that the methods be practicable from the standpoint of routine laboratory, give directly the necessary information regarding characteristics of the fuel and be sufficiently precise to permit their use as specification tests.

Defining "volatility" as the property of a substance which causes it to be dispersed readily into the air, the author states that volatility as regards fuels is understood to indicate the quantity of fuel that will evaporate into air under definite conditions, so as to be enabled to speak of volatility as a definite quantitative property, and discusses both operating and starting volatility. Since the fuel must be evaporated into the air-fuel mixture before it can be burned, volatility is a very important characteristic of fuels and can be expressed conveniently as the percentage of the fuel which could be evaporated at a specified temperature into air at atmospheric pressure when the air and fuel are present in definite proportions by weight. Another and practically equivalent measurement would be the temperature at which the fuel in a given air-fuel mixture would be evaporated completely or to some definite percentage, this being indicative of the volatility characteristics that affect complete utilization, crankcase-oil dilution and the like. A fuel that might be very satisfactory from the standpoint of continuous operation where a large percentage of the fuel was vaporized might not permit starting even at moderately low temperatures; therefore, the starting volatility, or the volatility at low temperatures with only a small percentage of the fuel vaporized, must also be right if the fuel is to be wholly satisfactory as regards volatility. Starting volatility can be measured by the quantity of fuel that must be supplied to produce at some chosen low-temperature a given lean air-fuel mixture or, more simply stated, a mixture that will explode.

Unsatisfactory features of the Engler distillation-test are enumerated, a simple test for starting volatility that anyone can make is presented and the specification of fuels is treated. Of the last subject it is said that although complete distillation data on a fuel give valuable information to the refiner or to the laboratory worker, it seems that, for specification, two points on the equilibrium distillation-curve would be adequate to fix the suitability of the fuel.

IN connection with the work in which the Bureau of Standards is cooperating with the National Automobile Chamber of Commerce, the American Petroleum Institute and the Society of Automotive Engineers on the measurement of the starting characteristics of fuels in internal-combustion engines, some work has also been done on laboratory test-methods of indicating the volatility characteristics of fuels. This paper is a preliminary presentation of some of the developments along this line and should be regarded purely as a progress report.

Motor Fuels

The motor fuels in general use today consist, not of one or of a few chemical compounds, but of a great variety of compounds ranging in boiling-point from about 36 deg. cent. (96.8 deg. fahr.), or lower to above 225 deg. cent. (437 deg. fahr.). Measurements of fuel volatility are complicated for this reason, for it is not in general feasible, as in the case of pure compounds or two or three component mixtures, to calculate volatilities under one condition from data secured under very different conditions. The complication due to the presence of a large number of compounds is increased by the fact that gasolines necessarily vary in composition from time to time as new crudes and methods of refining become available and, as a result, "gasoline," as a *definite* substance or mixture of compounds, does not exist. Consequently, precise measurements of volatility on a gasoline or fuel mean little except as regards that particular sample, and the accumulation of data such as are available for work on pure compounds are not available for automobile fuels. What is needed then, as regards fuel volatility, is a simple method or methods of measuring the volatility of individual-fuel samples. These methods should be (*a*) practicable from the standpoint of the routine laboratory, (*b*) give directly the necessary information regarding characteristics of the fuel and (*c*) be sufficiently precise to permit their use as specification tests.

The dictionary defines "volatility" as the property of a substance which causes it to be dispersed readily into the air. This term is used generally in a comparative sense; thus, "as volatile as ether". To speak of volatility as a definite quantitative property, volatility as regards fuels will be understood here to indicate the quantity of fuel that will evaporate into air under definite conditions.

Operating and Starting Volatility

Regarding operating volatility, the fuel must be evaporated into the air-fuel mixture before it can be burned; accordingly, volatility is a very important characteristic of fuels and can be expressed conveniently as the percentage of the fuel which could be evaporated at a specified temperature into air at atmospheric pressure when the air and fuel are present in definite proportions by weight, as, for example, 14 to 1. Another and practically equivalent measure of volatility would be the temperature at which the fuel in a given air-fuel mixture would be evaporated completely or to some definite percentage, say to 95 per cent, for instance. Such a measurement would indicate the volatility character-

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istics of the fuel which affect complete utilization, crankcase-oil dilution and the like.

As to starting volatility, the engine must be started before it can be operated and, in general, starting temperatures are much lower than operating temperatures. Also, we are primarily concerned here with the question of producing at the starting temperature a mixture that will fire, even at the expense of only partial evaporation and utilization of the fuel for, once the engine starts, its temperature rises rapidly and more complete evaporation takes place. A fuel that might be very satisfactory from the standpoint of continuous operation where a large percentage of the fuel was vaporized might not permit starting, even at moderately low temperatures; therefore, the starting volatility, or the volatility at low temperatures with only a small percentage of the fuel vaporized, say 10 to 20 per cent, must also be right if the fuel is to be wholly satisfactory as regards volatility.

Air-fuel mixtures that may be too lean to give satisfactory operation will fire in the engine but, to obtain even these lean mixtures at low temperatures, it is necessary to supply relatively large quantities of fuel by the use of the choke or primer so that a sufficient amount of the constituents that will evaporate at these temperatures will become available. Starting volatility can be measured by the quantity of fuel which must be supplied to produce at some chosen low-temperature a given lean air-fuel mixture or, more simply stated, a mixture that will explode.

Tests for Volatility

Not many years ago, gasolines generally were purchased on the basis of specific gravity; or rather, gravity Baumé, which is an arbitrary scale having a definite relation to specific gravity. This specification was fairly satisfactory so long as the gasolines were derived from a single type of crude, but the advent of gasoline from other fields soon brought to light the fact that, while these fuels showed a low test on the gravity scale, they were decidedly more volatile than the test indicated. Consequently, a distillation test for volatility was adopted. The Engler distillation consists in evaporating a charge of 100 cc., of fuel in a specified manner from a specified flask and observing the temperatures at which various percentages are distilled over. This type of test has long been recognized as unsatisfactory for indicating quantitatively the volatility of fuels in the engine. The two principal reasons that the test is not satisfactory are as follows:

(1) The Engler test is a "batch" distillation in which the fuel vapor is drawn from the system as it forms, and evaporation at any stage of the process is taking place in the presence of a vapor that has been formed at practically the existing temperature and that is not representative of the fraction of the charge which has been evaporated previously

(2) In an atmospheric distillation, evaporation takes place at a fuel-vapor pressure of 1 atmosphere, 760 mm. (29.92 in.) of mercury; whereas, in the engine, the vapor pressure of the fuel is in the neighborhood of 15 to 20 mm. (0.59 to 0.79 in.) of mercury; that is, only 2 or 3 per cent of atmospheric pressure. Vapor temperatures at 760-mm. (29.92 in.) vapor-pressure for a given percentage evaporated may be 100 deg. cent. (180 deg. fahr.), higher than the corresponding temperatures for evaporation under engine conditions, and the composition of say the first 20 per cent evaporated will be decidedly different in the two cases.

It should not be inferred from the foregoing statements that the present form of distillation test is worthless. It gives valuable information regarding the relative volatility of fuels and permits the specification of types of fuel that have been found to give satisfactory service; however, results are not readily translatable into expected performance in the engine and do not permit a direct quantitative comparison of fuels.

Referring again to starting volatility, the primary consideration in fuel tests is to be able to rate fuels in the *order* of their performance in the engine; that is, to be able to say that one fuel is better or worse than another and to state how much better or worse. A simple test for starting volatility that anyone can make was suggested by Dr. H. C. Dickinson, and is as follows:

> Place a small quantity, 10 to 20 cc., of water in a 500-cc. wide-mouthed flask; measure into the flask with a capillary tube a small amount of fuel, say 10 cm. (about 4 in.) on the tube; cork the flask and shake well. The function of the water is to create a disturbance in the flask and to promote evaporation of the fuel. Place the flask in an ice bath or a bath at the desired low temperature. After waiting a few minutes to allow the fuel that has been evaporated at the higher temperature to condense to equilibrium, remove the stopper and test the mixture for explodability with a small gas flame or a spark. A mild explosion may result in which the mixture burns slowly down to the bottom of the flask, or it may not burn or explode at all. A mere enlargement of the igniting flame is to be disregarded.
>
> This procedure is repeated with larger or smaller quantities of fuel until the quantity that will just give an explosive mixture is found. Say that this is 8.5 cm. (3.35 in.) on the capillary pipette. Suppose this procedure is repeated with a second fuel and it is found that 17 cm. (6.70 in.) on the tube is required to produce an explosive mixture. It is evident that the first fuel is more volatile than the second, since it requires only half as much to provide enough vapor at the test temperature to produce an explosive mixture. Consequently, if the capillary pipettes are calibrated as to volume, knowing the specific gravity, the weight of fuel put into the flask can be calculated. The weight of air in the flask also can be calculated from its volume and temperature and the existing barometric pressure. From these data, results can be expressed in terms of the air-fuel ratio that must be *supplied* in order that an explosive mixture will be formed.
>
> Experiment has shown that, under these conditions, a mixture of about 30 parts by weight of air to 1 part by weight of fuel will just give an explosive mixture. Consequently, the barely explosive mixture of air-and-fuel vapor that results from a 3 to 1 air-fuel mixture supplied must be about 30 to 1, and the fuel is then only about 10 per cent exaporated. The distinction between air-fuel ratio supplied and resultant air-fuel vapor mixture should be kept in mind. The proportions of air and fuel in the leanest explosive mixture can be determined approximately by determination of the least quantity of fuel that will produce an explosive mixture in the flask at some temperature at which the fuel is completely vaporized, or a light petroleum fraction that will completely vaporize at the low temperature can be used.

An elaboration of the foregoing simple apparatus is shown in Fig. 1. A regular-stock flask, *a*, having three necks, is equipped with a spark-gap, *b*, and a small air-driven stirrer, *c*, described by C. E. Waters[2], mounted in glass tubes through corks as shown. The corks are covered with tinfoil to prevent rapid absorption of gaso-

[2] See *Industrial and Engineering Chemistry*, May, 1924, p. 493.

line vapors and are protected from the bath liquid on the outside by a winding of gum splicing-tape. This flask is mounted in a low-temperature bath, *d*, that also can be stirred with an air-driven propeller, *e*. The large stopper must fit the flask closely enough to prevent appreciable loss of fuel vapor and yet must not offer sufficient resistance to cause the flask to burst from the explosion of a charge. The construction consisting of a bobbin formed of two thin aluminum discs, *f* and *g*, with a cork core, *h*, fastened to a short wooden rod, *i*, and wound with heavy woolen yarn, *j*, as shown, has been found to be safe and adequate. Leakage through the

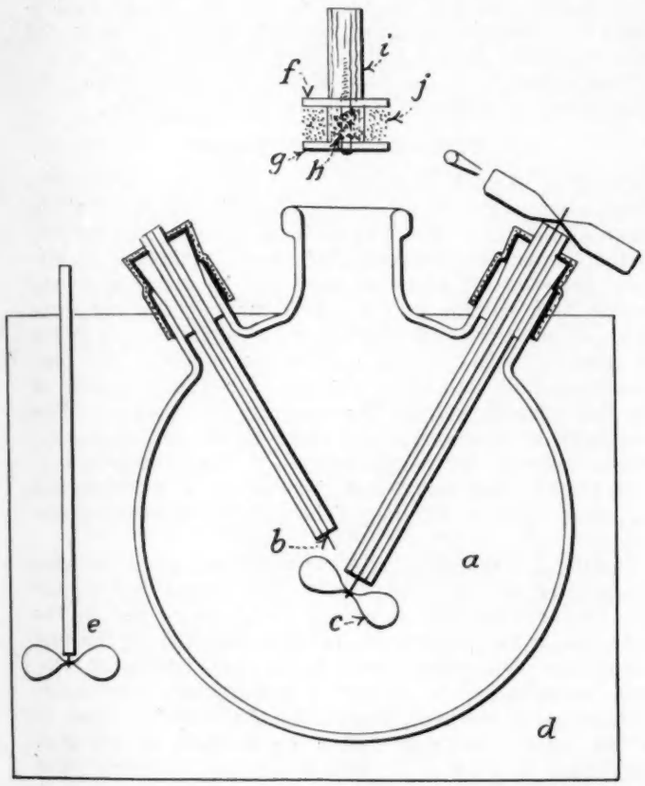

FIG. 1—BOMB FOR STARTING-VOLATILITY MEASUREMENT OF FUELS
A 500-Cc. Glass-Flask, *a*, in a Stirred Bath, *d*, Is Fitted with a Spark-Gap, *b*, and an Air-Driven Stirrer, *c*, Mounted in a Capillary Glass Tube Set in a Cork. Fuel Is Measured into the Bomb; It Is then Brought to Equilibrium at Some Low Temperature and a Spark Is Passed To Test Explosiveness. The Minimum Quantity of Fuel Required To Produce an Explosive Mixture in the Flask at the Test Temperature Can Thus Be Determined

capillary tube carrying the 1.5-mm. (0.059-in.) stirrer-shaft is negligible.

The handling of small quantities of fuel in capillary pipettes by suction in the usual way is somewhat fussy and the micro-pipette shown in Fig. 2 has been devised to facilitate accurate measurements; it is a capillary tube that has been calibrated for volume with weighed quantities of mercury. The fuel in the plain micro-pipette *k* is controlled by a small piston consisting of a wire, *m*, that is roughened at one end with a knife and a small quantity of cotton fibers, *n*, wound on it to fit the capillary. This piston, when moistened with the fuel, forms an excellent means of filling and discharging the pipette. A bubble of air several centimeters long is always between the piston and the fuel.

A better construction of the compound micro-pipette *o* is also shown. Here, a capillary having about twice the bore diameter of the measuring tube *p* has been sealed-on to form a cylinder in which the piston

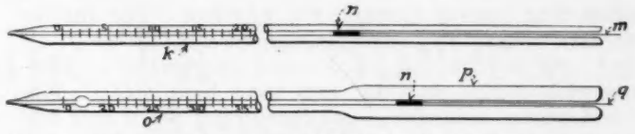

FIG. 2—MICRO-PIPETTES FOR MEASURING SMALL QUANTITIES OF LIQUIDS
A Capillary Tube, *k*, of from 0.6 to 1.0-Mm. Bore, (0.024 to 0.039 In.) Is Graduated for Volume and Fitted with a Piston Composed of a Bit of Cotton Fiber, *n*, Wrapped on the Roughened End of a Small Wire, *m*. Liquid Is Drawn into the Pipette and Delivered by the Motion of the Piston. A Better Construction, Shown in the Lower View, Has the Piston Operating in a Capillary Tube of Larger Bore, *p*, Sealed to the End of the Pipette *o*. Volumes of Gasoline Can Be Measured Accurately to 0.001 Cc.

works. This prevents the piston *q* from coming into contact with the measuring tube and reduces drainage-error. With such pipettes having a convenient bore-diameter, 0.6 to 1.0 mm. (0.024 to 0.039 in.), it is easy to measure small quantities of liquid with great precision. The drainage error of the 0.6-mm.-bore tube may be only 1 or 2 per cent with gasolines when the pipette is not discharged too rapidly. The spark points should be set from 3 to 5 mm. (⅛ to 3/16 in.) apart, and a good battery-coil or hand-driven magneto should be used.

In using this apparatus, care should be taken that the large stopper does not fit too tightly, and that the burning of a portion of a too-weak charge in the spark, resulting in a small displacement of the stopper, is not mistaken for an explosion. Such action indicates that a small percentage more of fuel will give a true ex-

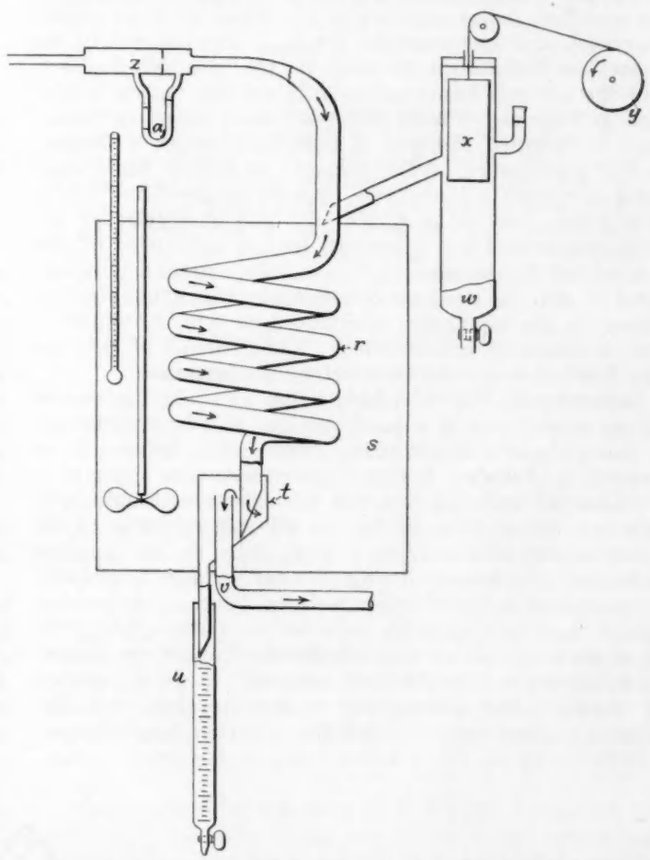

FIG. 3—APPARATUS FOR EQUILIBRIUM DISTILLATION OF FUELS
Fuel Is Displaced from the Reservoir *w* into the Copper Helix *r*, by the Steady Fall of the Clock-Controlled Plunger *x*. Air measured at the Orifice Meter *z*, Also Enters the Helix. Fuel Vaporizes into the Air in its Passage through the Helix To Attain Vapor Equilibrium at the Temperature of the Bath. Uncondensed Fuel Is Separated in the Suction Trap *t* and Is Measured in the Tube *u*. The Air-Fuel Vapor Mixture Goes to Waste. Thus, the Percentage of the Fuel That Will Evaporate at the Temperature of the Test in a Given Air-Fuel Mixture Supplied Can Be Determined

plosion that carries through the mixture. The results with this apparatus are surprisingly reproducible—1 to 2 per cent of the fuel—and some interesting correlations with engine-starting tests have been made. The method seems somewhat time-consuming when one has to feel around for the proper mixture; however, for specification work, it would be necessary only to make tests with the specified quantity of fuel at the specified temperature. An explosion passes the fuel; failure to explode rejects it. The temperature of the test and the quantity of fuel supplied should be chosen in the light of engine tests at low temperatures.

Considering operating volatility further, it at first appeared that information on the dry-points of fuels in given air-fuel mixtures might be obtained by placing the fuel in a flask, as shown in Fig. 1, on a portion of the flask bottom that had been ground to give a matte surface that shows-up very minute quantities of liquid. However, further work on this has not, as yet, given very promising results.

A method that does offer promise of permitting measurements of fuel volatility over the whole range from 0 to 100 per cent evaporated in any desired air-fuel ratio will be illustrated following the delivery of this paper. The demonstration set-up consists of a pair of helices formed of ¼-in. copper-tubing soldered together lengthwise as a pair to give equality of temperature in each helix. Fuels and air are fed into the tops of each of the two helices at equal rates in such proportions as to supply approximately a 14 to 1 air-fuel mixture. The air and fuel travel together in the helix, as in an engine manifold, the unevaporated liquid is trapped-out in the separator bulbs and drained to the graduated tubes, and the air-fuel vapor mixture is carried to the burner tips and burned. With different fuels supplied, difference in mixture richness is indicated by the difference in the appearance of the flames. A yellow flame indicates richness; a blue flame, correct proportions; and a thin flame, very weak mixtures. The quantities of the fuels evaporated are measured by the quantities of unevaporated liquid separated out. This double-helix apparatus will be used to demonstrate the principles involved in the apparatus illustrated in Fig. 3, which is now in course of construction. The elements of this design have shown very satisfactory performance.

Referring to Fig. 3, a long helix, *r*, of ⅜-in. copper-tubing is mounted in a bath, *s*, which can be maintained at the desired temperatures. This helix delivers to a separating chamber, *t*, that is provided with a drain to a graduated tube, *u*, for the unevaporated liquid and with an exhaust tube, *v*, for the air-fuel mixture. Fuel is fed into the helix from a large tube, *w*, by the displacement of a loosely fitting plunger, *x*, that is allowed to descend at a controlled rate by a drum, *y*, driven by a clock mechanism. This may be an alarm clock with the drum mounted on the minute-hand shaft, or one of the many types of clock that are used to drive recording charts. The mainspring is disconnected, and the clock is driven by the weight of the displacement plunger. A series of drums or of displacement plungers permit variation in the rate of fuel feed. The air is fed to the helix from a low-pressure system—1 lb. per sq. in. is sufficient—through an orifice meter, *z*. The rate of flow is measured by the reading of the water manometer *a*, and the calibration of the orifice.

In operation, with the bath *s* at the desired temperature, the fuel-flow, determined by the clock rate, the diameter of the drum *y* and the diameter of the displacement plunger *x*, is set at a rate that experience has shown is slow enough to permit the attainment of equilibrium, and the air-flow is set to give the desired air-fuel ratio, taking into account the volume rate of feed of the fuel and its specific gravity. After equilibrium is attained, requiring probably a few minutes, the rate at which liquid collects in the drain tube is observed; from this, the rate of supply being known, the percentage evaporated can be calculated readily.

Specification of Fuels

A series of such observations at various temperatures gives what might be termed the equilibrium distillation-curve of the fuel. From these data, possible engine performance can be predicted. Of course, complete equilibrium between air and fuel may not be attained in the engine and, to this extent, performance may not come up to expectations; but the test data indicate what might be possible with 100-per cent performance. The temperatures indicated, for instance, for 100 per cent of the fuel evaporated, are the temperatures that would be necessary to accomplish the same result in the engine. Dry-points will fall in the range of from 50 to 70 deg. cent. (122 to 158 deg. fahr.), instead of from 200 to 225 deg. cent. (392 to 437 deg. fahr.) as in the Engler distillation.

Complete distillation-data on the fuel gave valuable information to the refiner or to the laboratory worker but, for specification, it seems that two points on the curve would be adequate to fix the suitability of the fuel completely. One point would be in the vicinity of complete evaporation to secure a satisfactory operating-volatility; for instance, to specify that the fuel shall at 60 deg. cent. (140 deg. fahr.) be at least 95 per cent evaporated in a 14 to 1 fuel-air mixture supplied. The other point to fix starting volatility would be taken at some low temperature, and the specification might read that at —10 deg. cent. (14 deg. fahr.) the fuel shall be at least 15 per cent evaporated in a 2 to 1 air-fuel mixture supplied. These figures are simply picked out of the air for illustration and do not represent suggestions as to specifications for fuels that would be suitable for use in internal-combustion engines.

This then is the story of what seem to be some promising leads as regards the measurement of fuel volatility. Possibly, the final test will be another story altogether; however, as stated previously, this is simply a progress report, although it has expanded itself into a statement of things hoped for as well as things actually accomplished.

Airplane and Airship: Their Spheres of Economic Usefulness

By H. F. PARKER[1]

ANNUAL MEETING PAPER

NO oral discussion followed the presentation of this paper at the Annual Meeting in Detroit last January. A written contribution was subsequently received and, in accordance with our usual practice, was submitted to the author for a reply.

For the convenience of the members an abstract of the paper precedes the discussion so that some idea of the subjects covered can readily be obtained. Those who desire to refer to the complete text as originally printed together with the illustrations used will find the paper in the February, 1926, issue of THE JOURNAL.

ABSTRACT

ALTHOUGH the generally accepted spheres of usefulness of the airship and the airplane are usually based on their comparative ranges of operation and their speeds, the suitability of either of these types for a given purpose is primarily dependent on two classes of factors, those fundamentally dissimilar and those roughly similar. Conclusions as to relative usefulness should be based on a consideration of the dissimilar characteristics, which include aerodynamic efficiency, size and comfort.

Aerodynamic efficiency governs range and, since it determines fuel consumption, influences the cost of operation. The size required depends on the paying loads that are available for carrying. Comfort concerns passenger-carrying only.

As the propeller efficiency, rate of fuel consumption and ratio of weight of fuel carried to gross lift are similar in both types of aircraft, the range must depend on the L/D factor, that is, the ratio of gross lift to thrust. Although it is not customary to apply this ratio to airships, comparative curves for the airplane and the airship on this basis show a surprising superiority for the airship, not only at speeds of 60 or 70 m.p.h. but at higher speeds that have not yet been attained. In the matter of fuel consumption, an airship of 150-ton capacity traveling at 70 m.p.h. requires only one-quarter the fuel per ton-mile, and at 105 m.p.h. only one-half the fuel per ton-mile that is needed to propel 1 ton of airplane 1 mile at either speed.

Partly nullifying the advantage of the airship because of lower fuel-consumption has been the waste of lifting-gas that occurs in maintaining equilibrium when the weight has been reduced by the consumption of fuel. Notwithstanding this waste the airship can still compete with the airplane on an equal basis in the matter of fuel consumption at a speed of 70 m.p.h.; but through water-recovery and hydrogen-burning the waste is no longer necessary.

With regard to size, consideration is given to the effect of dimensional laws on the dead-weight of both types of aircraft. Assuming that the dead-weight of airplanes increases with the increase in size under the 3/2 law, the further assumption is made that 10 tons is the weight at which the law begins to operate; in airships, the factors operating are different from those of airplanes and do not become effective until sizes are reached far in excess of those contemplated at present.

Asserting that airplanes and airships of the same size are not likely to come into direct competition, the author then examines the fields in which each type is likely to prove useful.

Among the conditions affecting the comfort of passengers are found to be the relative amounts of space available on the two types of craft, and the various motions encountered, such as rolling, pitching, bodily vertical motion, and vibration.

But the observations made from the standpoints of aerodynamic efficiency, size and comfort, are said to be subject to modification by additional factors, of which the most important are (*a*) initial percentage of useful load, (*b*) initial cost per unit of gross weight, (*c*) relative operating-costs, (*d*) insurance and safety, and (*e*) rate of depreciation, each of which is discussed in detail; and reference is made to the causes leading to the Shenandoah disaster.

The conclusions reached are that, on account of aerodynamic superiority, the airship will be used wherever possible for carrying passengers in comfort, but a large field exists in which it cannot be used because of insufficient loads; that the airship will continue to be a long-range, the airplane, a short-range vessel, but these distinctions will be affected largely by the volume of traffic available; that although the cost of transportation per ton-mile is greater by airplane than by airship, this fact will not seriously limit the use of the airplane within its own field, the comparative magnitudes of the fields of heavier-than-air and lighter-than-air operation being similar to those of rail and water transportation; and that, inasmuch as the two types are complementary, the successful operation of either one will react to the benefit of the other.

THE DISCUSSION

E. P. WARNER[2]:—Mr. Parker has given a very able presentation of the case for the airship, but it seems to me that his comparison is at some points a little unfair to the heavier-than-air craft. The first such point to strike my attention is the formula for range that is included in the paper. For airships the formula as given is perfectly correct, but for airplanes it would be necessary to include another term representing the decrease of power required for flight with decreasing weight as fuel is used. The inclusion of that added factor, which is the logarithm of the ratio of initial to final weight, would convert it into what we call the Breguet range formula and, in the case of the typical commercial airplanes, would amount to an increase of about 40 per cent in extreme radius of flight. Something of the gap between the Los Angeles and the DH-34 would then be closed.

The position of the airship has been somewhat optimistically regarded in the calculation of its aerodynamic efficiency at very high speeds, and the setting of those figures against the ratios of commercial load given in Fig. 1. Mr. Parker takes the disposable load of an airship as 50 per cent, but even with the most favorable assumptions, as he indicates later in the paper, that must be reduced about 4 or 5 per cent for emergency ballast and similar necessities.

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If the speed of the airship were to be increased to a point where it would compete directly with the airplane, however, the stresses on the structure would be liable to increase nearly as rapidly as the square of the speed, and the structural weight would necessarily rise accordingly, as would that of the powerplant, so that an increase in maximum speed from 80 to 110 m.p.h., the least that would be possible if a 100-mile commercial speed were to be attained for direct competition with the airplane, would require an increase in the fixed weight of 25 per cent or more of total lift, thus cutting the commercial reserve from 45 to 20 per cent. With larger ships the position would, of course, be improved, but with any ship within the range of size that can be considered as practicable construction, the ratio of commercial load in short flights or those of moderate length would seem certain to be less than in the airplane of the same speed.

The application of the theory of dimensions to the prediction of the limiting size of airships is, as Mr. Parker stated, a very hazardous proceeding, and no two experts agree exactly on the conclusions from such analyses. Suffice it to point out that the stresses in fabric steadily increase with increase in diameter in the airplane and that the number of gas cells into which the ship is sub-divided is also likely to increase with increasing size, so that the total area of the fabric will increase somewhat more rapidly than the square of the linear dimension, and the possibility of having to increase its strength would certainly send its weight up somewhat more rapidly than the square. Powerplant weight, similarly, would ordinarily increase at a rate higher than L^3, as Mr. Parker's comparison is made on a basis of constant speed, and it is not only commercially desirable but necessary for control that speed be increased in very large sizes as the minimum speed at which the ship is controllable rises rapidly with increase in dimensions. The very large airship may not therefore show so much gain over the airplane as Mr. Parker's curves suggest, although of course no one will deny that the position of the lighter-than-air curve is considerably better.

Finally, there is the factor of initial cost to reckon with, and on that figures have been given for the airplane and the airship. It should be remembered, however, that the figures for airplane costs were taken in part from the experience of an engineer who has been concerned entirely with a very costly type of metal construction and with production of a small number of similar units, while the Zeppelin airship cost was figured at a time when the mark in Germany was undergoing its spectacular slide toward absolute zero, and the price set on the ZR-3 could hardly be duplicated under ordinary conditions. Even at the present time there are certain European countries where military airplanes are being purchased at a cost of under $5,000 per ton including the engine. Taking American figures on the airplane, however, and American estimates on airship costs, it seems that about $8,000 per ton for airplanes in moderate production and from $15,000 to $20,000 for airships would be a fair and directly comparable estimate.

H. F. PARKER:—Professor Warner's remarks on the range formula for airplanes are perfectly sound; the correction he suggests should be applied in arriving at the extreme range. If the L used in L/D be defined as initial lift, the correction might be interpreted as a change in L/D with duration of flight, and an allowance might be made for it in arriving at the form constant used in Figs. 3 and 4. It is, however, more of theoretical than of practical interest, for to take advantage of it the speed of the craft must be continuously changed to maintain the optimum L/D. In practice pilots usually fly at constant air-speed or constant engine-speed, in which case a falling off occurs in the L/D which largely negatives the gain from the reduction in weight. It should be noted that the ranges shown in Fig. 1 are not extreme ranges, but ranges at a given speed. The purpose of the figure was to show the necessity for making the comparison at the same speed, rather than to demonstrate any superiority in range for the airship. Had the range for the Los Angeles been estimated, theoretically, at the speed assumed for the DH-34, 120 m.p.h., the gap between the two craft would have been almost completely closed. In Fig. 1, 50 per cent useful load was allowed not only two of the airships, but also the PN-9; it is equally fair for all three craft, though as pointed out later in the paper it is not a regular operating-condition. Furthermore the PN-9 was allowed its actual extreme range, whereas much greater ranges might have been shown for airships had lower speeds been chosen. An airship of 10,000,000 cu. ft., for example, flying at 40 m.p.h. could circumnavigate the globe at the latitude of New York City without refueling.

If it be assumed that the proportions at present adopted in airship structures must remain substantially unchanged, and that unit powerplant weights must do likewise, an increase in speed would involve a reduction in the useful load. It is however within the power of the designer to avoid this loss completely. The structure must be designed to withstand both static and dynamic loads and must have a satisfactory margin of safety against both. In the earliest designs static stresses only were considered, as the speed was so low that aerodynamic stresses were relatively negligible. Then followed a period of simultaneous increase in speed and increase in the ratio of length to diameter, which resulted in the dynamic stresses exceeding the static and culminated in the ZR-2 disaster. The present trend is toward shorter and fatter ships. This is indicated by a comparison between the Shenandoah, the Los Angeles and the new British ship of 5,000,000 cu. ft. capacity being built by Vickers. These are respectively 8.70, 7.20 and 5.35. This shortening process is accompanied by lower relative dynamic stresses and by greater resistance to the dynamic stresses that do occur, due to the rearrangement of the material in the structure. An increase in speed from 80 to 110 m.p.h. should come well within the range that can be taken care of by this change in proportion without change in dead-weight. Even if this method were not available, to increase the strength against dynamic loads would not involve a proportionate increase in weight. In the report on the ZR-2 disaster it is estimated that the strength against these loads could have been doubled for an addition of 4 tons to the dead-weight. To restore the original factor of safety without change of shape in increasing the speed from 80 to 110 m.p.h. would thus reduce the useful load only by 5 per cent.

At 110 m.p.h. the horsepower required for propulsion is 2.6 times that necessary at 80 m.p.h. This would seem to call for a corresponding increase in the powerplant weight. On a basis of equal speed however it is fair to assume equal unit weight for the powerplant, a condi-

(*Concluded on p.* 401)

Headlighting Situation in the District of Columbia

By R. E. Carlson[1]

Annual Meeting Paper

ABSTRACT

HEADLIGHT regulations in the District of Columbia prior to May 3, 1925, required two white non-dazzling headlights visible 200 ft. ahead and so adjusted that the beam should not rise more than 42 in. above the ground at a distance of 75 ft. in front of the vehicle. As this rule did not require bright lights, most vehicles were operated with dim lights and police officers often directed the dimming of the lights. Tests made by the Bureau of Standards with 400 cars that were offered voluntarily for the purpose indicated that approximately 73 per cent of the head-lamps were out of focus, 46 per cent were improperly directed and 54 per cent were regarded as glaring. Questionnaires addressed to car builders revealed that, although a majority of the companies that replied adjusted the head-lamps at the factory and half of them expected their distributers to check the adjustment, a considerable gap exists between the factory adjustment and proper adjustment at the time the car is delivered to the user.

In 1925 the 68th Congress enacted a traffic act for the District creating the office of Director of Traffic with authority to make reasonable regulations as to motor-vehicle equipment. Headlight regulations formulated under this act became effective on May 3, 1925, and required sufficient illumination to reveal any substantial object the size of a small child on the road 200 ft. ahead but prohibited a glaring or dazzling light and specified that if the bright portion of the main beam did not rise more than 42 in. at a distance of 75 ft. ahead of the vehicle the headlight would comply with the non-dazzling provision.

A campaign of education was conducted for some time, calls were made on dealers, garages, service-stations, and fleet operators, instructions in headlight adjustment were distributed with the cooperation of the automobile associations, Board of Trade and National Safety Council, and numerous lamp-adjustment stations were established, one car company equipping its 13 agents with light tunnels and arranging for 2-weeks' free adjustment for car-owners. Talks and demonstrations were given at "safe drivers' schools" and before police officials and police-court judges.

The effectiveness of this work is indicated by the fact that, whereas in 21 months prior to the going into effect of the new regulations, 57 per cent of the total number of automobile accidents occurred at night, only 23 per cent occurred at night in the 8¾ months after May 3, 1925. Two of the largest taxicab companies reported that their night accidents had been greatly reduced in number. Although the new system is imperfect and has not been enforced consistently, the results show that the use of approved devices and controlled beams can be most helpful.

IN view of the volume of criticism of the present standard system of headlight regulation, it may be of interest to consider some of the benefits that are obtained in the District of Columbia by a reasonably close adherence to the principles of this system.

Prior to May 3, 1925, headlight regulations in the District required that

> Motor vehicles shall be equipped with at least two lamps on the front affixed in such a manner as to show a white light visible for a minimum distance of 200 ft. to the front thereof. . . . It shall be unlawful . . . to use any headlight that is blinding or dazzling to persons using the streets provided that lights shall be so adjusted and arranged that the beam shall not rise at a greater height than 42 in. from the ground 75 ft. in front of the vehicle.

An attempt made under these regulations to improve headlight conditions was not very successful. Most vehicles were operated with dim lights, in fact, police officers frequently admonished motorists to dim their lights. An examination of the regulations will indicate why the use of dim lights was encouraged, since two oil lanterns hung at the front of the car would meet the legal requirements.

Tests made of headlights on about 400 cars by the Bureau of Standards in 1923 indicated that approximately 73 per cent of the lights were out of focus, 46 per cent were improperly aimed and 54 per cent were regarded as glaring. The cars whose headlights were inspected were driven voluntarily to the Bureau in response to a public notice that tests were to be held. It is reasonable to assume that the condition of the equipment on these cars was better than on the average car, inasmuch as the car owners displayed sufficient interest to submit their cars for test. Included in these tests were a number of new cars, and a large proportion of these were found to have headlights that were adjusted improperly.

Car Builders Adjust Lamps at Factory

To secure reliable information concerning the practice of motor-car builders with respect to headlights, the following letter was sent in August, 1923, to 51 companies. Thirty-four replies were received, nine companies did not answer and eight companies were out of business.

> Subject: Headlight Adjustment
> Gentlemen:
>
> To secure data upon which to base a campaign for better headlight adjustment in the District of Columbia, the Bureau of Standards recently tested the headlights on some 400 cars. This survey revealed the fact that 73 per cent of the headlights were out of focus, 54 per cent were glaring, and 46 per cent were not properly tilted.
>
> Quite a number of very new cars included in these tests had improperly adjusted headlights. In order to have more complete information, we would appreciate receiving the following information:
>
> (1) What is your factory procedure to insure correct headlight adjustment before cars are turned over to dealers or factory distributing branches?

[1] S.M.S.A.E.—Engineer, Bureau of Standards, City of Washington.

(2) What is the procedure at distributing points to ensure proper adjustment before cars are delivered to buyers?

(3) How do service men and service departments of dealers adjust headlights?

(4) What type of lens is used on current models?

(5) What instructions are given in the instruction book accompanying each car for headlight adjustment?

The above information will be used in connection with the work the Bureau is doing in cooperation with the enforcement officers, the Safety Council, the Automotive Trade Association, motorist associations, distributors and garages, and your courtesy in furnishing it will be very much appreciated.

Respectfully,
GEORGE K. BURGESS, Director.

The replies indicated that five companies inspected the lamp equipment as it was received from lamp manufacturers to ensure proper focus of the lamp filament in the reflector. Twenty-seven companies stated that head-lamps were adjusted at the factory, while in four cases adjustment was taken care of, supposedly, by branches and distributers.

With reference to the procedure by distributers, 15 replies stated definitely that distributers were supposed to check the adjustment. Four companies had no information about the adjustment after the cars left the factory and the remainder of the 34 made no definite statement on this subject.

Replying to question (3) of the letter, how do service men and dealers adjust head-lamps, 14 manufacturers said that they gave special instructions to service men and the rest either did not give special instructions or had no information on the subject.

In answer to question (5) concerning instructions in handbooks, 12 manufacturers had instructions in the handbook, 13 had no instructions, two issued special circulars, and the others had no information on the subject.

From this survey it is apparent that a considerable gap exists between adjustment at the factory and proper adjustment at the time the car is delivered to the user. Car builders generally have not done their part in pointing out the advantages of good lighting nor have they, as a whole, organized to give satisfactory service on headlights.

NEW REGULATIONS ADOPTED

The District of Columbia Traffic Act of 1925, passed by the 68th Congress, created the office of Director of Traffic and required that he "make reasonable regulations with respect to brakes, horns, lights, mufflers, and other equipment." Accordingly, regulations based on our standard system were formulated and became effective on May 3, 1925, requiring the use of approved types of equipment. The following are two of the most important provisions:

(*g*) *Construction, Arrangement and Adjustment.*—The head-lamps and head-lamp devices shall be so constructed, arranged and adjusted that they will at all times under normal atmospheric conditions produce ample driving light so as to reveal any person, vehicle or other substantial object the size of a small child, on the street 200 ft. ahead, except when the motor vehicle is operated on a street so well lighted that any substantial object on the street 200 ft. ahead is clearly discernible when the head-lamps are dimmed or when the vehicle is coming over the brow of a hill or under other circumstances which would throw the full beam upward so as to produce glaring or dazzling light. Head-lamps shall not project a glaring or dazzling light to persons approaching or to persons whom such lights may approach.

(*h*) Head-lamps will comply with the provisions covering glaring lights if none of the main bright portion of the head-lamp beams rises above a horizontal plane passing through the lamp centers parallel to the level road upon which the loaded vehicle stands and in no case higher than 42 in. 75 ft. ahead of the vehicle.

It will be noted that these regulations encourage the use of bright lights but that when used they must be properly adjusted. Under previous regulations dim lights were in favor, and, naturally, when a new rule was introduced and bright lights were required, a large number of which were glaring, conditions at first were most unsatisfactory and the regulations were criticized bitterly.

EDUCATIONAL CAMPAIGN CONDUCTED

An educational and adjustment campaign under my general direction had been under way for some time prior to the going into effect of the new regulations, which had in mind:

(1) Provision of adequate facilities for head-light adjustment

(2) Education of drivers as to the advantages of good lights and then encouragement to use the facilities for adjustment

(3) Education of enforcement officers and judges to obtain the most effective cooperation in the application of the regulations

Personal calls were made on car dealers, garages, service-stations, and fleet operators. Instructions in adjustment were prepared and distributed, and numerous adjustment stations were installed. The cooperation of organizations, such as the Automotive Trade Association, the Board of Trade, the American Automobile Association, and the National Safety Council, was secured to spread the information and foster compliance with the regulations. One large car company arranged for 2 weeks' free adjustment, each of its 13 agents being equipped with a headlight tunnel. The newspapers supported the plan and printed a large amount of information on headlights. Talks and demonstrations were given at "safe drivers' schools" and before police-court judges, traffic officers and precinct commanders. Although a considerable amount of work has been required to put the system on a going basis, those interested feel that the results obtained justify the expenditure of the time and money notwithstanding the division of authority between the police and the new traffic director has hindered effective enforcement of the regulations.

NIGHT ACCIDENT PERCENTAGE REDUCED ONE-HALF

In a period of 21 months prior to May 3, 1925, 57 per cent of the total number of accidents occurred at night; from May 3, 1925, to Jan. 20, 1926, approximately 23 per cent of all accidents were at night. The Director of Traffic attributes this reduction to the new headlight regulations and better understanding and use of head-lamps.

Two of the largest taxicab companies that had previously been using marker lights were required to spend several thousand dollars each to equip their cabs with legal lamps. After the regulations had been in force for some time, both companies commented upon the improvement in conditions that had resulted and ex-

pressed their unqualified approval. One stated that, whereas its previous average had been one bad accident per night, it had gone 1 month without a night accident at the time of writing. The other company said that its night accidents had been reduced materially and that all of its drivers preferred the bright lights that are now permitted.

Our present system is not perfect. Both its advantages and shortcomings are recognized, but we should make the best use of this system pending the completion of proposed research from which it is hoped something simpler and better will be evolved. Conditions are not entirely satisfactory in the District of Columbia from an adjustment standpoint, but, despite the fact that enforcement of the regulations has not been consistent nor sustained, a considerable amount of progress has been made. The results obtained in the reduction of night accidents show that our standard system involving the use of approved devices and controlled beams can be most helpful if properly used.

AIRPLANE AND AIRSHIP—THEIR ECONOMIC SPHERES OF USEFULNESS

(*Concluded from p.* 398)

tion that does not exist at present. Thus the Los Angeles, the type ship for the airship figures given in the paper, has engines weighing, bare, 6 lb. per hp. The power necessary for 110 m.p.h. could therefore be supplied at a unit weight of 2.3 lb. per hp. which may be compared with a unit weight of 1.5 lb. per hp. for modern airplane engines. The airship should suffer no disadvantage from these causes at speeds below 120 m.p.h.

The curve for the change in dead-weight with increase in size was computed directly from the Los Angeles percentages without any allowance being made for the detail changes that would accompany such an increase. This was done on account of the great difficulty of arriving at a fair estimate without making complete layouts. Dr. Arnstein has criticized the curve on the ground that it is unduly conservative. He states that he has laid out designs for ships up to 300 tons gross weight and has found the curve still falling at this point. Some features undoubtedly change adversely, but I believe that the final result is more in the direction indicated by Dr. Arnstein.

Professor Warner's figures would seem to indicate a unit cost for the airship twice that of the airplane. This however involves a comparison between costs that can be arrived at with a fair degree of accuracy on the basis of several years' experience and estimates for which not even a definite basis exists. In the case of the airplane he appears to have made a small deduction from current costs to allow for "moderate production," and in that of the airship to have made a relatively generous cut. Such an application of a correction factor, itself indeterminate, to an unchecked estimate, can easily lead to a result extremely wide of the mark. The first few airships built in America will undoubtedly be costly. The establishment of a new industry is involved; an organization must be created; new methods of construction must be developed or European methods adapted to American conditions; and many other factors enter which make it almost impossible at present to do more than guess how much it will cost to build an airship when production development has reached the stage that exists today in the airplane industry. It was for this reason that I used English figures, basing my case on actual costs as given in Parliamentary statements. Even then the comparison was less than fair to the airship, for the airplane costs were based on a production of about six units, whereas the figure for the airship was for a single ship only. Estimates made by Commander Burney, of the Vickers firm, for the six ships contemplated in his original scheme, worked out at only $6,000 per ton. As Vickers possessed the data necessary to make a reasonable estimate on the basis of previous experience, and were actually hoping to build these ships, I might with some reason have compared this figure with the $10,000 given for airplanes in similar production and claimed a material advantage for the airship.

AUTOMOTIVE RESEARCH

(*Concluded from p.* 350)

opinion that detonating characteristics of fuels should be investigated. Early investigators established the fact that for a given fuel detonation is a function of engine design. As a sort of summation from a popular standpoint of some work on the subject, C. F. Kettering presented before the Federal Oil Conservation Board the following equation.[5]

$$\text{Knock} = (P^x \times T^y)\, K + E$$

where

E = Characteristic of the engine
K = Constant for the fuel used
P = Compression pressure
T = Temperature of the charge

Fuels that are suitable for compressions much higher than the conventional are now produced in large quantity. However, before a gradual change to higher compression-ratios can be expected, the automotive industry must be assured that such non-detonating fuels shall be obtainable throughout the Country. Without doubt a number of strong inducements to change gradually to higher compression-ratios exist.

The Bureau of Standards, by raising the compression-ratio to 6½ to 1 and making those changes in the car which this would make possible from the point of view of equal performance has obtained an increase in part-throttle mileage of as much as 27 per cent; the conventional ratio being taken as 4½ to 1. Mr. Kettering states that actual test has shown that an increase in compression of one-half the above-mentioned amount gives about 20 or 30 per cent improvement in total mileage.[6]

Non-detonating fuels can be produced in increasing quantity, in response to demand. The demand will be determined by the design of the engines. For this reason, cooperative research between the petroleum and the automotive industry seems highly desirable. Suggestions by members of other subjects suitable for cooperative research of interest to both industries would be highly appreciated by the Research Department.

[5] See Complete Record of Public Hearings of the Federal Oil Conservation Board, Feb. 10 and 11, 1926, p. 37.

[6] See Complete Record of Public Hearings of the Federal Oil Conservation Board, Feb. 10 and 11, 1926, p. 38.

THE RUBBER INDUSTRY AND CRUDE RUBBER SUPPLY

LOW prices of rubber from 1921 to 1924 discouraged new plantings. These, indeed, declined steadily after 1918 and since 1921 plantings have been of very small proportions. While high prices are again stimulating activity, it requires from 4 to 6 years for new plantations to come into bearing, and 10 or 12 years to reach the full bearing stage. Thus, normal requirements for the next 5 years must be met primarily by plantations already set out and for the most part in bearing.

While accurate comparisons on a value basis are impossible over the period, it is significant that between 1914 and 1923 total rubber manufactures in the United States rose in value from $300,994,000 to $953,643,000. In 1911 only 10 per cent of the rubber imported went into tire production. Today four-fifths or more of the rubber received is used for automotive equipment, and the Rubber Association of America estimates that by 1930 tires will consume 87 per cent of the imports. Although crude rubber consumption and tire output are more than five times as large as in 1914, the number of wage-earners has increased only 86 per cent, indicating the extent to which machinery has replaced manual labor. Mechanical methods have made unusually rapid progress since 1921.

The total value of solid tires produced barely doubled from 1914 to 1923. In the same period the value of pneumatic casings manufactured increased over four-fold. In 1919, when quantity figures were first published, 1,455,000 solid tires were manufactured, a level not equaled in later census years. In 1921 production fell to 401,000 solid tires, rising in 1923 to 924,000, and, according to the Rubber Association of America, declining in 1924. Rubber boots, shoes and overshoes rank second to tires in the rubber industry; the value of such manufactures rose from $50,506,000 in 1914 to $106,605,000 in 1923.

Reclaimed Rubber

The manufacture and use of reclaimed rubber is a phase of the industry that has decided significance in a period of shortage. Utilization of reclaimed rubber has been extended since the beginning of 1925, and it promises to continue profitable. When crude rubber costs from 30 to 35 cents per lb. the use of reclaimed rubber in increasing quantities is economical, and with all indications for a high price-level in 1926 reclaimed rubber will probably continue an important factor in the trade. Output of reclaimed rubber rose from 30,000 tons in 1921 to 54,000 tons in 1923; the total output in 1925 exceeded, it is stated, 100,000 tons.

In tires, using more than 10 to 15 per cent of reclaimed rubber is doubtful economy. In other rubber goods a much larger percentage can take the place of crude rubber and in some hard rubber goods as little as 5 per cent of new rubber can be used without ill effects. In 1920 nearly 40 per cent of the rubber demand was supplied by reclaimed rubber but with the low prices of recent years the ratio of reclaimed to crude rubber used declined markedly. Crude rubber now stands fourth in United States import trade, coffee, silk and sugar alone surpassing it in value.

France has one of the most important rubber industries outside of the United States and dominates the world's export tire market. Italy's rubber manufactures have made great progress since the war and Italian tires now hold an important position in European markets. The larger European tire manufacturers depend primarily on export markets.

Rubber Supply and Price

For some 15 years prior to 1910 rubber prices, apart from temporary fluctuations, were tending to rise. The supply was then almost entirely derived from the native rubber of Brazil and other regions. Production, while gradually increasing, hardly kept pace with expanding new uses. As a result the price on the New York City market rose from an average of 67 cents in 1894 to $1.48 in 1909, reaching in 1910 a temporary high point of nearly $3.00 per lb. By that time requirements were being greatly increased by the development of the automobile. The rapid advance in prices had stimulated extensive planting of rubber estates in the Far East, and the output of these plantations began to come on the market in substantial quantities after 1910. By 1914 production of plantation rubber exceeded that of wild, and increased rapidly through 1920.

With the world-wide debacle of 1920 and 1921, rubber consumption was sharply curtailed, heavy stocks accumulated and prices dropped to unprecedented levels, below the production costs of many plantations. Voluntary restriction of output was tried for a time by a considerable group of operators and fruitless efforts were made to arrive at an agreement that would cover both British and Dutch plantations. Finally, in November, 1922, the British Government put into effect the scheme known as the Stevenson Restriction Plan.

For the better part of 2 years the restriction scheme appeared to have relatively little influence on prices, partly because producers in the Dutch East Indies, not covered by the scheme, were expanding output and partly because a considerable share of current requirements was being taken care of out of accumulated stocks. In the spring of 1924, with the temporary slackening of the rubber industry, the New York City price of ribbed smoked sheets fell to 17⅜ cents. By fall, consumption was again expanding rapidly. Prices had risen to around 35 cents by January, 1925. Then began the spectacular rise that carried prices to the entirely abnormal levels of last July. Since then they have receded somewhat but still are almost three times the level prevailing at the beginning of the year.

Restriction has not occasioned an actual reduction in the supply of rubber coming on the market. Exports from British territory dropped in 1924 to about 205,000 tons from a high point of 272,000 tons in 1922, but exports from Dutch territory in the same period increased from 102,000 to 175,000 tons. There is little promise of low prices for a few years.—*Commerce Monthly.*

STANDARDIZATION ACTIVITIES

(*Concluded from p.* 348)

of W. H. Graves the Subdivision on Black Baking Enamel is making a second series of cooperative exposure tests simulating service conditions to check the results of tests made in the laboratories in accordance with the tests specified in the proposed specifications for black baking enamel. Cooperative tests are also being made by the Subdivision on Leather Substitutes to determine whether the strip or grab method of determining the tensile-strength of leather substitutes is preferable. The Division has under consideration the desirability of establishing life tests for rubber parts such as door bumpers.

Production Division.—The Production Division is making a special study of the standardization possibilities in grinding and grinding machinery. Other subjects are being discussed in a general way.

Screw-Threads Division.—It is expected that definite reports on castle nuts, extra-fine screw-thread fits and tolerances, and tire-valve threads will be adopted at the April 12 Screw-Threads Division meeting. Other subjects under consideration are gaging of screw-threads, machine screw nuts and tap-drill reference tables.

Tire and Rim Division.—Division action has been taken by letter-ballot on pneumatic-tire dual mountings and it is expected that a report will be submitted for action at the Standards Committee Meeting. Balloon-tire standardization is being studied.

Transmission Division.—Reports are to be submitted at the April meeting of the Transmission Division on clutch facings, spline fittings, transmission nomenclature, and transmission brake-drums. It is thought that these subjects will be completed in time for action at the June meeting of the Standards Committee.

INTERNATIONAL STANDARDS CONFERENCE

Several Countries Sending Delegates to America for Meetings in April

The third international conference of the chairmen and secretaries of national standardizing bodies of foreign countries will be held in New York City from April 12 to 24 inclusive, at which time the International Electrotechnical Commission will also be in session. The schedule of meetings includes also a number of informal international conferences on subjects that are now before Sectional Committees working under the procedure of the American Engineering Standards Committee. Probably the most important of these will be the conference on international screw-thread standardization that will be participated in by representatives of Great Britain, Canada, Australia, and the United States. The principal items for discussion are with regard to the pitch of the ½-in size screws and the angle and form of the Whitworth and American Standard thread-forms. Following the Anglo-American informal conference on this subject, a general international conference attended by representatives of all the countries that will have delegates in America will be held. Other subjects on which conferences will be held with relation to work that has been done by Sectional Committees are bolts and nuts, limits for various classes of fits in machine work, gears, and ball bearings.

Delegates representing Great Britain, Belgium, Holland, Japan, Norway, Sweden, Germany, Switzerland, Checho-Slovakia, Poland, and Austria are expected to be present at the various conferences. The American delegates will include the Chairman and Secretary of the American Engineering Standards Committee, delegates chosen by the several Sectional Committees; representatives of the National Screw Thread Commission, and probably a number of unofficial advisory representatives.

This series of conferences is the first to be held in this Country and the Society and other national organizations, particularly those participating in standardization work under the procedure of the American Engineering Standards Committee, are interested in the results. None of the conferences will result in final action being taken on subjects under discussion, but it is hoped they will bring out important information that will be of service to the various Sectional Committees in the United States and standardizing committees of other countries in the development of national and international standards.

PREFERRED BALL-BEARING-SIZES LIST

Division of Simplified Practice Committee Reports Sizes for New Applications

Last January the Navy Department, in reviewing its various specifications, sought to determine to what extent the list of ball-bearing types and sizes could be reduced for industrial application, especially those that are carried in stock sizes. The Division of Simplified Practice of the Department of Commerce held a conference of ball-bearing manufacturers and users to consider the feasibility of preparing such a list and as a result the following committee was formed to make a report:

F. W. Gurney, *Chairman*	Marlin-Rockwell Corporation
G. R. Bott	Norma-Hoffman Bearings Corporation
H. E. Brunner	S.K.F. Industries, Inc.
E. R. Carter	Fafnir Bearing Co.
T. C. Delaval-Crow	New Departure Mfg. Co.
E. F. DuBrul	National Machine Tool Builders Association
R. M. Hudson	Division of Simplified Practice
L. N. Linsley	Navy Department
C. A. Mudge	Electro Dynamic Co.
R. S. Burnett, *Secretary*	Society of Automotive Engineers

At a meeting of the committee held at the offices of the Society early in March, a report was completed covering the annular, wide, angular, separable or open and the extra small series of radial bearings. The bearings selected for the preferred lists are Nos. 200 to 214 inclusive of the annular light series; 302 to 318 inclusive and 320, 322, 324, 326, 328, 330, 332, 336, and 340 of the annular medium series; 405 to 418 inclusive of the annular heavy series; 5200 to 5214 inclusive of the light wide series; 5302 to 5318 inclusive and 5320 and 5322 of the wide medium series; 5405 to 5418 inclusive of the wide heavy series; 7200 to 7214 of the angular-contact light series; 7302 to 7318 inclusive and 7320 and 7322 of the angular-contact medium series; 7405 to 7418 inclusive of the angular contact heavy series; sizes 5, 8, 10, 12, 15, 16, and 17 of the separable or open type; and sizes 34, 36, 38, and 39 of the extra small series. The selection of the foregoing preferred sizes reduces the respective types by amounts varying from 25 to 45 per cent of the number of bearings included in the S.A.E. Standards, on which the report of the committee was based. The next step taken by the Division of Simplified Practice will be to secure acceptance of the list by industry by calling a general conference of interests for approval of the program relating to the publication of this list and its distribution for general industrial acceptance. Inasmuch as the Society and the Ball Bearing Sectional Committee are still working on the standardization of the thrust and roller types of bearings, action by the Division of Simplified Practice looking toward the preparation of similar simplified lists of sizes will be held in abeyance until the standards can be completed and approved.

Applicants *Qualified*

The following applicants have qualified for admission to the Society between Feb. 10, and March 10, 1926. The various grades of membership are indicated by (M) Member; (A) Associate Member; (J) Junior; (Aff) Affiliate; (S M) Service Member; (F M) Foreign Member.

ADAMS, WILLIAM R. (A) superintendent, International Motor Co., *Plainfield, N. J.;* (mail) 632 Brookside Place.

AUNGER, H. MURRAY (F M) J. G. Brill Co., *Philadelphia.*

BRATTON, LIEUT. ANDRAL (J) 13th Field Artillery, Schofield Barracks, *Honolulu, T. H.*

BROWN, R. W. (M) in charge of engineering laboratory, Firestone Tire & Rubber Co., Firestone Park, *Akron, Ohio.*

CLARK, RONALD (A) managing director, Societe Anonyme Francaise North East, 17 Rue Villaret de Joyeuse, *Paris XVII, France.*

DAVIDSON, G. GRAHAM (J) draftsman, Consolidated Aircraft Corporation, *Buffalo;* (mail) 521 Lafayette Avenue.

DREXEL, DEFORREST W. (M) rail car engineer, Mack plant, International Motor Co., *Allentown, Pa.;* (mail) Box 512, Y. M. C. A.

FERGUSON, J. L. (A) service manager, William E. Bush, Inc., 1701 South Grand Avenue, *Los Angeles.*

FORBERGER, STEPHEN A. (J) designer, Wright Aeronautical Corporation, Paterson, N. J.; (mail) 37 Rose Terrace, *Newark, N. J.*

GIBSON, WILLIAM B. (A) vice-president and general manager, William B. Gibson, Inc., Van Ness Avenue and Eddy Street, *San Francisco.*

GODWARD, ERNEST ROBERT (A) chief engineer, Godward Vaporizer, Inc., *New York City;* (mail) 153 West 94th Street.

GOEHRING, EDWARD P. (J) chassis draftsman, Six Wheel Co., *Philadelphia;* (mail) 2714 West Somerset Street.

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Applicants *for* Membership

The applications for membership received between Feb. 15 and March 15, 1926, are given below. The members of the Society are urged to send any pertinent information with regard to those listed which the Council should have for consideration prior to their election. It is requested that such communications from members be sent promptly.

ANDERSON, ARTHUR W., experimental engineer, Borg & Beck Co., *Chicago.*

ANNICK, MICHAEL J., draftsman, Sheldon Axle Spring Co., *Wilkes-Barre, Pa.*

BAKER, HARRY C., engineer, Dayton Steel Foundry Co., *Dayton, Ohio.*

BALDAUF, PHILIP, JR., body engineer, Sayers & Scovill Co., *Cincinnati.*

BARLOW, CLINTON M., layout draftsman, Willys-Overland Co., *Toledo.*

BARRETT, CHARLES G., sales engineer, Nordberg Mfg. Co., *Milwaukee.*

BERRY, JAMES CUTHBERT, proprietor, Portland Street Garage, *Barrowford, England.*

BRION, LESTER, president, Peter A. Frasse & Co., Inc., *New York City.*

CARLE, WALTER, service manager, H. J. Ruddle Co., *Los Angeles.*

CASE, HAROLD W., junior mechanical engineer, National Advisory Committee for Aeronautics, Langley Field, *Hampton, Va.*

CEADER, JOSEPH D., manufacturing engineer, incandescent lamp department, General Electric Co., Nela Park, *Cleveland.*

CORNELL, EDWARD M., teacher of automotive subjects, Central High School, *City of Washington.*

COWELL, F. R., chief designer, Kirkstall Forge, Ltd., *Leeds, England.*

DAVIDSON, G. W., director and works manager, mechanical transport department, Ministry of Communications, *Cairo, Egypt.*

DE CAMP, RALPH D., president, Royal Motor Coach Co., Inc., Rahway, N. J.; president and general manager, De Camp Bus Lines, *Livingston, N. J.*

DUGGAN, JOHN ROSS, manager of exports, Westinghouse Union Battery Co., *Swissvale, Pa.*

EGYPTIAN LACQUER MFG. CO., Inc., *New York City.*

EVANS, RONALD CLEMENT, chief engineer, Elgin Street Sweeper Co., *Elgin, Ill.*

FERODO & ASBESTOS, INC., *New Brunswick, N. J.*

FISHER, RALPH E., sales engineer, C. G. Spring & Bumper Co. of Michigan, *Detroit.*

FITZGERALD, EDWARD, draftsman, Cruban Machine & Steel Corporation, *New York City.*

FULLER, ROSCOE HODGES, student apprentice, Rolls-Royce of America, Inc., *Springfield, Mass.*

GANNETT, ROBERT, mechanical engineer, Eclipse Machine Co., *Hoboken, N. J.*

GIBBONS, LEO I., technical sales engineer, B. F. Goodrich Rubber Co., *Akron, Ohio.*

GRANFELT, ERNEST H., draftsman, Sheldon Axle & Spring Co., *Wilkes-Barre, Pa.*

HAGER, THEODORE W., vice-president, Peter A. Frasse Co., Inc., *New York City.*

HANLAN, C. J., superintendent of motor equipment, Kaufmann's Department Store, Inc., *Pittsburgh.*

HAUSAMANN, GEORGE J., engineering department, Eclipse Machine Co., *Hoboken, N. J.*

HOLIHAN, DICK C., draftsman, Flint Motor Co., *Flint, Mich.*

HOYT, ALFRED O., general manager, Reliable Trucks, Inc., *Chicago.*

JACKSON, W. M. S., consulting engineer, Maedler Engine Corporation, Christensen Air Brake Co., Obturator Piston Corporation, and Sealtite Piston Corporation, *Cleveland.*

JORY, SAMUEL, engineer, Westinghouse Air Brake Co., *Wilmerding, Pa.*

KELECOM, PAUL E., civil engineer, Société de Servo Frein Dewandre, *Liége, Belgium.*

KOGSTROM, AXEL W., installation engineer, John Warren Watson Co., *Philadelphia.*

KUMPERA, TENY, assistant chief engineer, Gnome & Rhone Aircraft Motors Mfg. Corporation, *Paris, France.*

KYLE, ALBERT B., shop superintendent, W. P. Herbert Co., *Los Angeles.*

LEUTZ, CHARLES R., president, Golden-Leutz, Inc., *Long Island City, N. Y.*

LIDDELL, ROBERT P. F., chief engineer, Motor Improvements, Inc., *Newark, N. J.*

MCDONALD, HOWARD P., general foreman of automotive equipment, East St. Louis & Suburban Railway Co., *East St. Louis, Ill.*

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MARKS, CHARLES J., production engineer, Pratt & Whitney Aircraft Co., *Hartford, Conn.*

MEAD, ARTHUR B., vice-president, Peter A. Frasse & Co., Inc., *New York City.*

MILLS, H. L., general manager, United Sales, Inc., *Chicago.*

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PAUL, F. O., service manager, J. G. Brill Co., *Philadelphia.*

PAXTON, GEORGE B., laboratory assistant, Studebaker Corporation of America, *Detroit.*

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SCHWARZE, WILLIAM, JR., district service manager, White Co., *Philadelphia.*

SCOTT, D. O., general manager, Hydraulic Brake Co., *Detroit.*

SHOCK INDEPENDENT OIL CO., *Mount Joy, Pa.*

SKILLMAN, NEWTON, president, O. S. Bearing Co., *Detroit.*

SMARTT, JOHN, manager, Portland Street Garage, *Barrowford, England.*

SOCIETA ANONIMA AUTOMOBILI ANSALDO, *Turin, Italy.*

SOUTHWICK, LAURENCE FRANCIS, engineer, Vacuum Oil Co., *New York City.*

SPOHN, EARL M., draftsman, Continental Motors Corporation, *Detroit.*

STARKEY, W. CARLETON, vice-president and general manager, L. G. S. Mfg. Co., *Indianapolis.*

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TAUB, LOUIS, draftsman, Cadillac Motor Car Co., *Detroit.*

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VANE, JAMES P., corporation salesman, J. W. Leavitt & Co., *San Francisco.*

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